



Charles E. Kellogg

ISRAEL JOURNAL

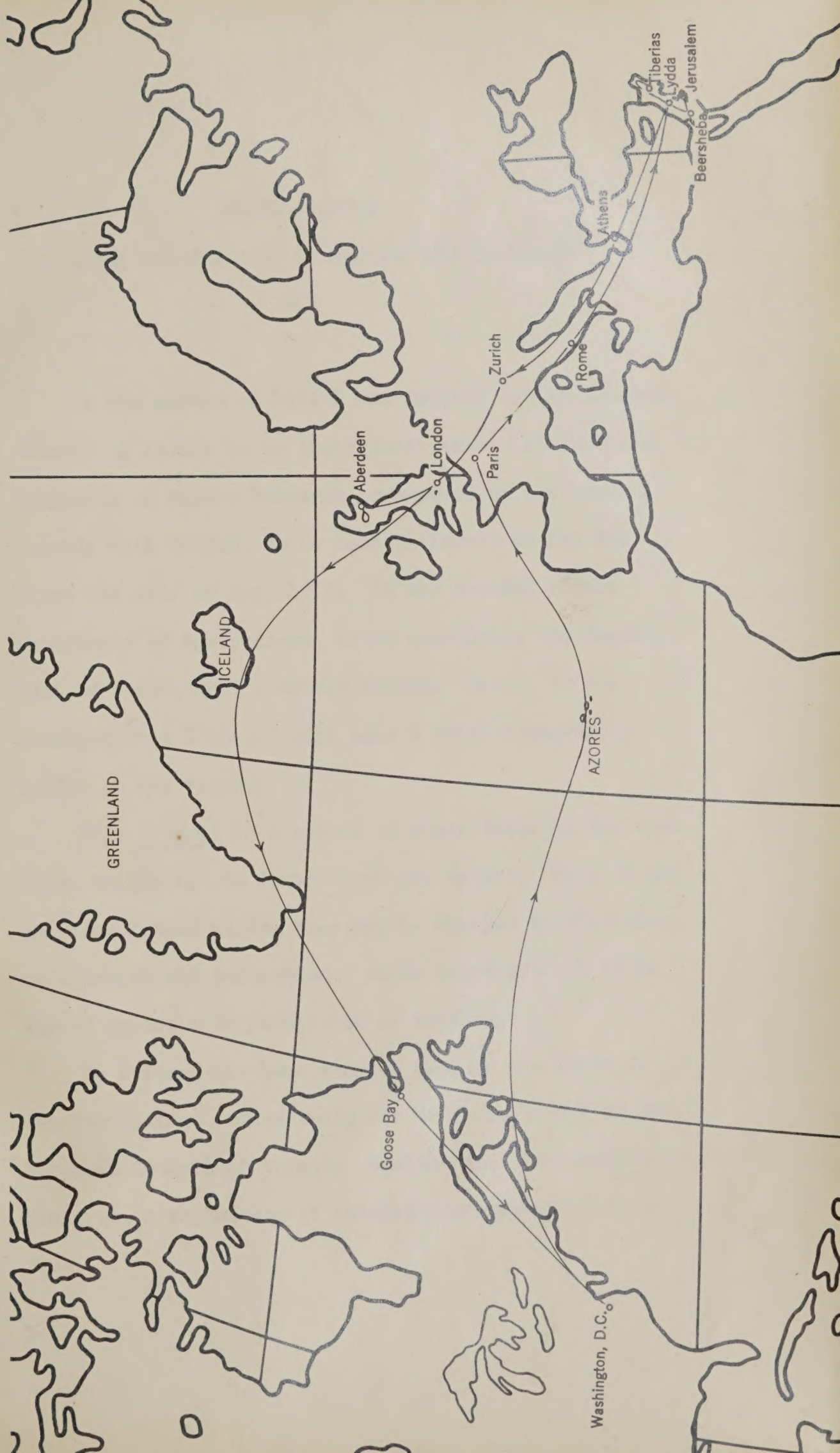
(Including brief visits in England and Scotland)

Washington to Jerusalem	7
Visit to Kiriat-Arnavim	17
Agricultural Experiment Station	75
Givat Brenner	80
Agricultural Experiment Station	84
Symposium in Jerusalem	81
Beerseheba and South	83
Beerseheba - Haifa	88
Haifa - Nazareth - Tiberias - Haifa	95
Symposium in Haifa	94
Acre - Lydda	97
Israel - London	99
Harpenden	103
Charles E. Kellogg	
Reading - Oxford	104
Aberdeen Scotland	107
London - Washington	117

Table of Contents

Washington to Jerusalem	2
Visit to Kiriath-Anavim	17
Agricultural Experiment Station	25
Givat Brenner	30
Agricultural Experiment Station	44
Symposium in Jerusalem	51
Beersheba and South	60
Beersheba - Haifa	68
Haifa - Nazareth - Tiberias - Haifa	76
Symposium in Haifa	89
Acre - Lydda	97
Israel - London	99
Harpender	101
Reading - Oxford	104
Aberdeen <i>Scotland</i>	107
London - Washington	117

Schematic Route of Travel Overseas
1952



ISRAEL JOURNAL

(Including brief visits in England and Scotland)

1952

In the autumn of 1951 I was invited by the Research Council of Israel to be their guest at an International Symposium on Desert Research, sponsored by the Council jointly with UNESCO, to be held in Israel during the first one-half of May, 1952. It was decided in the Department of Agriculture, after consulting the Department of State, that I should accept. Later, it was arranged that I should also make a brief stopover in London on the return.

This Journal is a record of notes taken on the spot, often in haste. No doubt there are errors. Some of the opinions formed at the time may be changed with further information and reflection. These notes are not to be quoted except with permission in writing.

No attempt has been made to include the whole of the Proceedings, since these are to be published by the Research Council of Israel. Besides the black-and-white pictures, a collection of colored transparencies is on file.

April 30

Fortunately, I go to the Washington Airport a bit early and find that my plane to New York is very late. I'm put on another due earlier, but also late, and leave at 2:38 p.m. EDT. We are down at Idlewild Airport in New York at 3:40 and wait a long time for baggage. Finally I get all set for the flight to Israel on Air France with a new ticket of transfer from El Al. We are away at 6:50 p.m. EDT or 11:50 p.m. Paris time. Dr. and Mrs. Richards, U. S. Salinity Laboratory, Professor and Mrs. J. B. Leighly, University of California, Professor F. W. Went, California Institute of Technology, and Dr. C. W. Thornthwaite, Sea-brook Farms, are in the party.

Here again I start one of these long sleepless nights in flight over the sea. Beginning about 8:00 p.m. we use an hour and one-half in eating a very fine dinner: (1) Apéritif, (2) salad, fruit, fish, (3) chicken, rice, vegetables, with sparkling wine, (4) ice cream, (5) cheese, (6) fruit, (7) tea, and (8) cognac.

After dinner I read and doze, and one day passes into another.

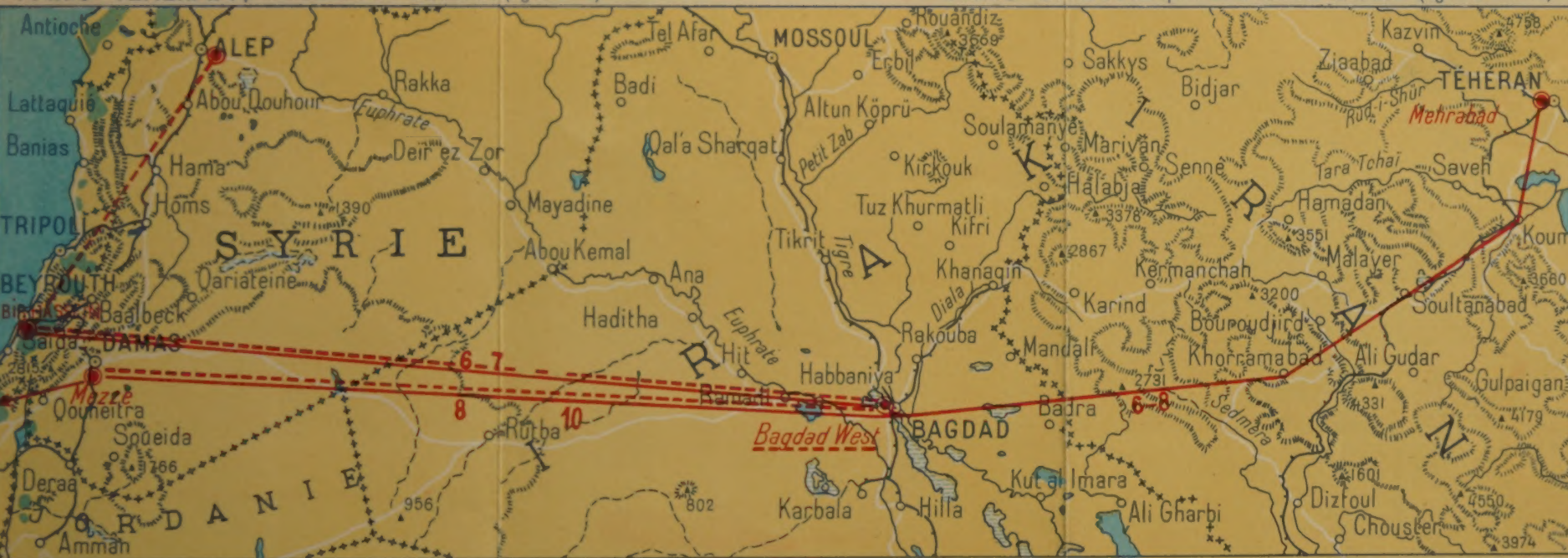






PARIS - TÉHÉRAN parcours : BEYROUTH - TÉHÉRAN (ligne n° 6)

PARIS - TÉHÉRAN parcours : DAMAS - TÉHÉRAN (ligne n° 8)



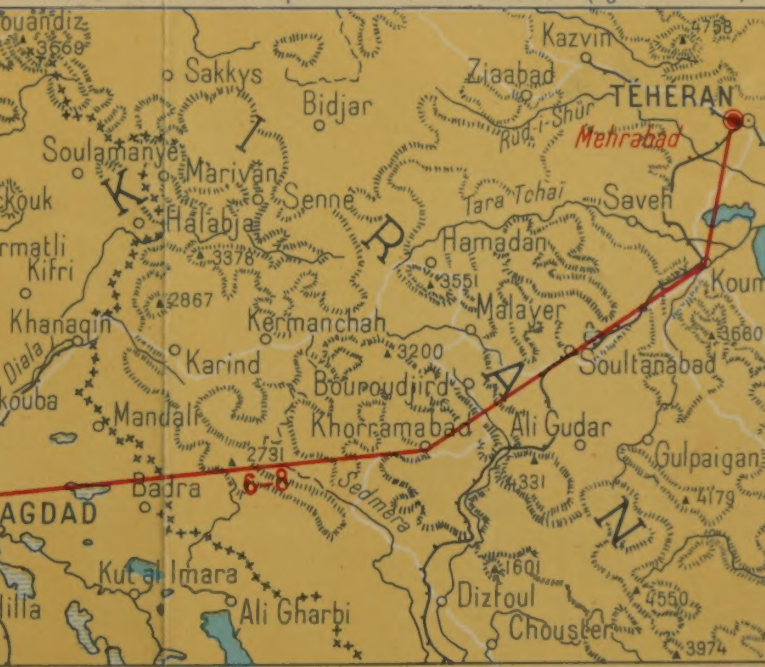
BEYROUTH - ISTANBOUL



Vers SALONIQUE Vers TEHRAN

PARIS - BAGDAD parcours : BEYROUTH - BAGDAD (ligne n° 7 fin)

PARIS - BAGDAD parcours : DAMAS - BAGDAD (ligne n° 10 fin)



Novembre 1951 Echelle : 1/5.000.000



Vers LE CAIRE

Mais il nous faut nous arracher à ces impressions pour continuer notre voyage, car Naples nous appelle. « Vedi Napoli e poi muori », « Voir Naples et mourir ». C'est un morceau du ciel tombé sur la terre ». L'Italien du Sud et le savant géographe Elisée Reclus se rejoignent dans cette enthousiaste exclamation. Du promontoire de Pausilippe à la pointe de Castellamare, l'œil ne se lasse pas de contempler les aspects les plus riants et les plus enchanteurs. Les îles de Capri, d'Ischia, de Procida, le Vésuve, Sorrente, enfin. Quels noms chargés d'évocations... mais la réalité ne déçoit pas l'imagination de ceux qui la contemplent.

Si la grande ville a déchu de la primauté qu'elle occupait encore il y a vingt-cinq ans et avec ses 900 000 habitants se situe loin derrière Rome, qui en compte plus d'un million et demi, et même Milan, qui dépasse le million, elle demeure toutefois la métropole de l'Italie du Sud et le second port après Gênes de l'Italie tout entière.

Nous survolons ensuite Salerne, célèbre par le souvenir de Robert Guiscard et de ses Normands, qui posséda ensuite une célèbre école de médecine. Le golfe de Tarente est bientôt atteint. Nous dominons la Calabre au relief tourmenté et nous traversons la mer Ionienne non sans avoir entrevu à l'extrémité de la péninsule de Morée, le cap Matapan.

Egale en superficie et en population à la Corse, l'île de Crète présente, comme elle aussi, un profil montagneux et certains de ses sommets avoisinent 2.500 mètres. Dans notre traversée de la mer Egée, nous entrevoyons le Dodécannèse. Nous laissons au nord l'île de Chypre, colonie anglaise de population grecque, pour atteindre enfin le Liban aux cimes neigeuses. Sa capitale, Beyrouth, beau port moderne et bien outillé, capitale de l'Etat du même nom, possède également des universités célèbres. La distance est courte de Beyrouth à Damas, florissante citée bâtie sur les bords du puissant Barada, issu des montagnes de l'anti-Liban et qui y a formé un vaste oasis.

D'autres souvenirs nous assaillent aux approches de l'Euphrate, un des fleuves du « Paradis terrestre ». Nous dominons bientôt son impétueux jumeau, le Tigre, dont les larges et abondantes eaux arrosent la ville de Bagdad. Cette métropole de l'Irak, avec ses 800.000 habitants, n'a pas dégénéré depuis Haroun-al-Raschid. Ses minarets colorés, ses bulbes de falence bleue ou verte, évoquent déjà la Perse.

Après avoir bordé une zone montagneuse, nous franchissons les chaînes parallèles du Louristan séparées par des vallées profondes et pittoresques. Nous retrouvons ensuite la steppe monotone avec une certaine mélancolie, car nous sentons que la fin de notre voyage approche. Bientôt, en effet, s'étend devant nous la citadelle, le quartier européen de Téhéran avec ses jardins et ses ombrages, à l'arrière plan, le massif de l'Elbrouz.

La Perse, ce pays aimable illustré par Montesquieu et que l'on se plaisait à rapprocher du nôtre, a aujourd'hui quelques soucis. Souhaitons-lui de retrouver sa gaieté et son insouciance.

THE BARATIN BROTHERS MANAGE IN BARBIZON

LES PLEIADES TÉL. 25
In a restful, flowered setting - Luxurious suites
Fine Restaurant
Traditionally friendly welcome
In NEW-YORK : 129 East 60th Street
LE VEAU D'OR, Select French Restaurant

Cadillac SALES and SERVICE
OFFICIAL DISTRIBUTORS Paris-Area
HENRY BINDER - 31, rue du Colisée
CORNER of Av. FRANKLIN-ROOSEVELT
PARIS Tél. ELYsées 57-66

AUTOMOBILES
De Soto
SOCIÉTÉ ROBLOU
DISTRIBUTEURS POUR LA FRANCE
Magasin d'exposition : 138 CHAMPS-ÉLYSÉES. ELY 39-05
STATION SERVICE :
68 Bd Bourdon, Neuilly-s/-Seine — Tél. MAI 10-27, 10-28

M. G. RILEY MORRIS WOLSELEY
SOLE DISTRIBUTOR :
MOTO-COMPTOIR
98, Rue de Courcelles
PARIS-17^e - Tél. : CAR. 11-40

AIR FRANCE

mais c'est la France...

... avec ses grandes traditions d'hospitalité souriante, de confort délicat, d'élégance discrète et raffinée.

NOS RÉFÉRENCES

Les pionniers d'Air France s'appelaient Mermoz, Guillaumet, Noguès, Saint-Exupéry... Avec eux, tant d'autres qui, à l'âge héroïque de l'aviation commerciale, partirent dès 1919 les premières routes du ciel ! Dans les conditions incroyables d'audace, ils poursuivirent leur tâche forgeant les grandes traditions qui sont, aujourd'hui encore, l'honneur de notre Compagnie.

Ces hommes formèrent nos premiers équipages et leur transmittent la flamme qui les animait.

A l'heure actuelle l'héritage des pionniers a été maintenu et accru. Air France, riche de son expérience trentenaire, assure l'exploitation d'un réseau qui couvre plus de 220.000 kilomètres et relie les cinq parties du monde.

UNE FLOTTE AÉRIENNE PARMIS LES PLUS PUISSANTES

La flotte Air France compte plus de 112 appareils ligne, dont 77 quadrimoteurs modernes.

19 « Constellation » affectés aux grandes liaisons internationales et de l'Union Française.

27 « Douglas DC. 4 » et 31 « Languedoc » desservent les lignes européennes, méditerranéennes et africaines.

Outre ces appareils, Air France utilise 35 bimoteurs « Douglas DC. 3 » affectés au Réseau Postal et aux Réseaux d'Indochine, d'Afrique Centrale, d'Océanie, de Madagascar et des Antilles.

Entretenue dans des ateliers très modernes et parfaitement outillée, cette flotte est à même d'assurer un service sans défaillance sous toutes les latitudes et par tous temps.

UN RÉSEAU MONDIAL

Air France exploitant un réseau mondial qui touche 65 pays et 174 escales, offre à sa clientèle une gamme de possibilités exceptionnelles... En 1950, les avions d'Air France ont parcouru 48.452.899 km, soit 1.211 fois le tour de la terre. Où que vous soyez, et quel que soit le but de votre voyage, partout Air France met à votre disposition une organisation soucieuse de vous procurer un service attentif et varié.

May 1

At 7:10 a.m. we are down at Santa Maria in the Azores for breakfast. On again for Paris at 8:00 a.m. We reach Orly Field near Paris at 3:00 p.m. Almost at once we are taken across the field to a waiting plane for the last leg of our journey. This is said to be a non-stop flight to Lydda. (I hope our French stewardess is wrong; she calls it a "non-flight stop" to Lydda.) I hope my baggage gets transferred properly, but it wouldn't surprise me if it didn't. The plane is full and apparently has been held some time for us. We are in the air at 3:50 p.m.

As we cross western Switzerland I am able to see the odd Alp through the clouds. The sky is free of clouds but very hazy as we fly over the Po Valley, along the coast near Genoa, and on by Rome. The air becomes more hazy, and it is soon dark beyond Rome.

We have a very nice cold dinner, but I ask for plain wine instead of sparkling wine. After dinner I try to read but it is not much use. The light is dim and I'm sleepy -- but the kind of sleepy that makes me simply dull, not the kind that lets one really sleep. The trip would not have been tiring if I could have ended it in Paris, but $7\frac{1}{2}$ hours more is too much.

Finally the hours grind by and we are dropping into
Lydda Airfield at 11:25 p.m. Paris time.

ISRAEL GUIDE MAP

SURVEY OF ISRAEL

Published by the STATE

OF ISRAEL TOURIST DEPARTMENT

1:500,000



First class motor roads	Other roads, dry weather	International boundaries	Heights in metres
Second class motor roads	Railways & Station	Principal antiquities of interest	Police Sta., Post
Other roads, all weather	Wadis, dry except during rains	Ancient sites	Airports

No gradient on the principal roads exceeds 1 in 6 1/2. Road information is not guaranteed as conditions are liable to change.
The grid squares on this sheet for convenience of reference, have been lettered & numbered in the margin. Thus, Jerusalem may be located as being in square K.6.
The grid lines refer to Survey of Israel co-ordinates and are numbered in small type at each 20 kilometres East & North of an origin that is outside the country to the S. W.

Compiled, drawn and printed by Survey of Israel, January 1950

May 2

This turns out to be 1:25 a.m. Israel time, and a new day is here. We find much confusion. No one is here from the Research Council since they did not know that we were coming on Air France. I had suspected this but unfortunately had no opportunity in Paris to send a message. Somehow an exceedingly alert young lady of the Tourist Bureau has my name and takes me through the formalities a-flying. With her help I get the last rooms in Tel-Aviv for the party. The others are slow getting through, especially Thornthwaite (who may have irritated the officials in some way). We get a cab to the Gazit Hotel in Tel-Aviv and are ready for bed about 3:45 a.m.

I am up at 9:30 in a beautiful morning. Professor Went and I have breakfast in the hotel. I'm still sleepy: absent mindedly I ask the waiter for bacon instead of eggs. He just smiles, and brings me sardines.

Superficially at least, the city here looks much like any Mediterranean city, especially in Algeria.

After breakfast I have a much-interrupted press conference with a reporter who calls the Research Council people for us. After many tries he reaches Dr. Sambursky, who sends his very able secretary, Miss Valero, to look after us.

May 2

This turns out to be 1:25 a.m. Israel time, and a new day is here. We find much confusion. No one is here from the Research Council since they did not know that we were coming on Air France. I had expected this but unfortunately had no opportunity in Paris to send a message.

Someone an exceedingly alert young lady of the Tourist Bureau has my name and takes me through the formalities - flying. With her help I get the last room in Tel-Aviv for the party. The others are also getting through, especially Thorndike (who may have irritated the officials in some way). We get a cab to the Gaiety Hotel in Tel-Aviv and are ready for bed about 3:15 a.m.

I am up at 9:30 in a beautiful morning. Professor Wont and I have breakfast in the hotel. I'm still sleepy: absent minded I ask the waiter for bacon instead of eggs. He just smiles, and brings me sardines.

Superficially at least, the city here looks much like

any Mediterranean city, especially in Algeria.

After breakfast I have a much-disrupted press confer-

ence with a reporter who calls the Research Council people

for me. After many tries he reaches Dr. Szambrsky, who

sends his very able secretary, Miss Valero, to look after us.

She is very apologetic about not meeting us early this morning, but explained that they didn't know we were coming on Air France. Apparently what happened was that El Al had changed its schedules in New York. When they got the order to get us out on April 30 they could do it only by transferring us to Air France. ^{1/}

Miss Valero arranges for two cars to take us to Jerusalem. It is a bit too bad that members of our party keep wandering off. I find it very difficult to keep them together to make arrangements for their own welfare and comfort.

We leave by cars for Jerusalem at 1:40 p.m. It is bright, sunny, and warm. On the outskirts of Tel-Aviv there is a great deal of apartment building going forward. We pass over a large flat area that looks to me to be drained wet alluvial or marine soil. Beyond, we drive into low uplands with red sandy soils. Some of the roadcuts show reddish-brown soil. We pass some old Arab villages that are now in bad shape. They were partly destroyed and abandoned during the fighting in 1948.

^{1/} Added later: Until I took the return journey by El Al, I didn't realize how fortunate I had been to go out by Air France.

A part of the old road to Jerusalem as shown on the maps is included in Trans Jordan by the Armistice terms. The town of Latrun, an important strategic spot and road center on the old main road to Jerusalem, is now in Trans Jordan. Thus, it was necessary for the Israelites to build a new road in bad country to the south of Latrun.

We pass fairly near the airport at Lydda. I see some more of the red soil on the gently-sloping uplands, with reddish-brown soil on the lower slopes and in the lowlands.

In many places along the road are fairly good evergreen windbreaks. Many of these seem to be some species of cyprus. We pass some plantings of oranges and I see a little barley. Quite a bit of the land appears to be more or less derelict or neglected, likely for institutional reasons following the 1948 war.

We pass a military camp near the road and also a big supply depot of the Jewish Agency. Then I see more citrus, some wheat, and some olive plantings.

We pass through Ramle and it is said that the population includes about 50,000 Israelites and some 5,000 Arabs. Here there are many beautiful Bougainvillea vines. After passing the old road turning to Latrun, we drive through a large treeless, houseless area. Some of the land is in fallow and some of it has small grains, especially barley. Weeds are quite bad. Back from the road I see some old Arab villages and

new Jewish settlements. Our driver says that two years ago this place was nearly like a desert. The soil is dark brown.

We also pass some of the "transition camps" for the Yemenite Jews that have recently come to Israel from Yemen.

We pass from this coastal region into the low mountains that continue to Jerusalem. Many of the soils are thin, stony, and light colored. Generally speaking, there are two associations of soils in the hills: (1) on hard limestone, Lithosol and transitions to well-developed Terra Rossa and (2) on the soft limestone, Lithosol and transitions to well-developed Rendzina. Some of the lower slopes and local Alluvial soils are dark brown or dark reddish-brown; and there are patches of rolling dark brown soil. These areas may be remnants of old terraces, I don't know.

I see a few small patches of thickly-sown maize on the contour. Potatoes are grown in favored places. These are mainly small areas of dark brown or dark reddish-brown soil from local alluvium. Although water is scarce for irrigation, there are some local installations. Most of the slopes are very stony indeed.

Along a great deal of the highway, strips of eucalyptus have been planted. Near the pavement the weeds have been

filled with all spray; but on the whole the work was quite bad.

We pass a Yaman... irrigation in the far... strongly rolling, and... is light grayish-brown. As we pass... landmarks, I try to... are not far from the... Arab villages in the background.



K-2094 May 2, 1952

West of Jerusalem. A new settlement for immigrants on Terra Rossa.

As we approach... border to Trans-Jordan. Part of the... this, stony soil is nearly open, but some of it has... young plantings of pine. Settlements are being established... on some of the stony... first glance with... of course one can be... proper terracing and... highly productive.



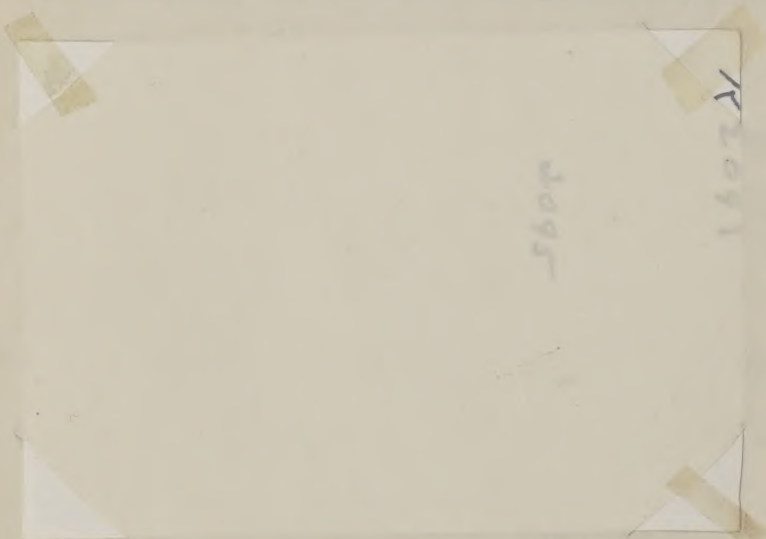
K-2095 May 2, 1952

West of Jerusalem. Nearly abandoned Terra Rossa.

against the Arab... the Terrarist State



K-3094 May 2, 1952
West of Jerusalem. A new settlement
for immigrants on Terra Rossa.



K-3095 May 2, 1952
West of Jerusalem. Newly abandoned
Terra Rossa.

killed with oil spray; but on the whole the weeds are quite bad.

We pass a Yemenite cooperative farm with sprinkler irrigation in the favored places. Beyond we go over strongly rolling, extremely stony land. Most of the soil is light grayish-brown with a few patches of dark reddish-brown. As we pass another new settlement for Yemenite immigrants, I try to take some pictures. Here again we are not far from the frontier, and I see old abandoned Arab villages in the background.

As we approach Jerusalem, we come quite near the border to Trans Jordan. Part of the steeply sloping, thin, stony soil is nearly open, but some of it has nice young plantings of pine. Settlements are being established on some of the strongly-sloping Terra Rossa soils. At first glance much of this soil looks to be hopeless; but of course one can be easily fooled by Terra Rossa. With proper terracing and management, much of it can be made highly productive.

We pass an old Arab village not far from Jerusalem that is still occupied by Arabs who fought with Israel against the Arab League. Many of them even fought with the terrorist Stern Gang.

We hurry through Jerusalem to the Eden Hotel. I am assigned room 28, which later must be shared with someone else, and then we have our lunch.

After a little visit-chat with Dr. Ben-Hur, I prepare to go on a tour of some of the synagogues in the orthodox section of Jerusalem. This is probably foolish, because my back is already ached.

We set out in the morning, marking the beginning of the visit to the Buharim people who came early that is a kind of new city. The border goes right through the



the old city is in Trans Jordan and the new city is Israel.

K-2096 May 2, 1952

Between the two is West of Jerusalem. Arab village.

a few yards to several hundred yards across which no one dare walk since there are armed guards prepared to shoot on either side. Except for this no-man's land, most of the shell-damaged buildings have been torn down or repaired, although some scars are evidence of the 1948 war.

The Sabbath begins with the blowing of a shofar at 6:00 p.m. during sundown. Our guide takes us into several of the synagogues attended by the strict, old-fashioned,

We hurry through Jerusalem to the Eden Hotel. I am assigned room 28, which later must be shared with someone else, and then we have our lunch.

After a little chit-chat with Dr. Sambursky, I prepare to go on a tour of some of the synagogues in the orthodox section of Jerusalem. This is probably foolish, because my back is already tired.

We set out in late afternoon before sunset, which marks the beginning of the Jewish sabbath. We start by visiting the Bukarin section, occupied mostly by Jewish people who came early from Russia. We then go to a section that is a kind of copy of the old city of Jerusalem in the new city. The borderline between Israel and Trans Jordan goes right through the city of Jerusalem. Generally speaking, the old city is in Trans Jordan and the new city in Israel. Between the two is a no man's land varying in width from a few yards to several hundred yards across which no one dares walk since there are armed guards prepared to shoot on either side. Except for this no-man's land, most of the shell-damaged buildings have been torn down or repaired, although one sees many evidences of the 1948 war.

The sabbath begins with the blowing of a whistle at 6:41 p.m. marking sundown. Our guide takes us into several of the synagogues attended by the strict, old-fashioned,

orthodox Jews from Poland and other parts of east-central Europe. Women are not allowed to take any part in the services, although they can observe them through screens where they stand in adjoining rooms or balconies. We also see a few synagogues for the Yemenite Jews, who also take the old forms very seriously.

As I gather the general idea, these Jewish men and boys are rejoicing that there is a God and that they are alive. There is a great deal of half mumbling and half reading from books and chanting and singing. Part of this is conducted by a leader who takes one part and the congregation takes another part.

Some of these orthodox Jews go to extremes in dress with long coats, broad elaborate fur hats, beards, and little curls hanging down in front of the ears, originating from long hair above the temples.

We pass through one section of this general area where the extreme orthodox Jews try to prevent any automobiles on the street during the sabbath, that is from sundown Friday evening to sundown Saturday evening. As soon as the sabbath begins, they put barricades of barbed wire, stones, and odd bits of lumber across the street. This is contrary to city regulations because of the need to have the streets open for fire trucks and police cars. We happen

to be at one barricade when a police car comes. A large and noisy crowd gathers. I notice a lot of loose stones about and decide that it would be unwise to stay to see the outcome.

We walk through a nice looking area, "Talmund Street," occupied by orthodox Jewish families who are supported almost entirely by outside contributions. It seems obvious that they divide their time between religious exercises and the raising of very large families.

I am glad to get back to my hotel about 9 o'clock. This has been too long a walk for my back so soon after the long plane trip. I skip dinner for two oranges and go to bed.

JERUSALEM

OLD AND NEW

100 200 300 400 500
METERS

- 1 app. indicates the Israel-Transjordan Demarcation Line
2 the Western Limits of the Israel Military Zone
The area between the two lines can only be entered with special permit.

קו שביתת הנשק 1949 בין ישראל לעבר הירדן
קו הגבול המזרחי של האיזור הצבאי הישראלי
הכניסה לשטח בין הקוים אסורה
בלי רשיון מיוחד.



May 3

I am up about 8:30 and have breakfast with some members of our party. About 10:00 a.m. Professor and Mrs. Reifenberg (Professor of Soils, Hebrew University) come to call. We chat for a while and then the Reifenburgs take Dr. and Mrs. Richards and me for a short tour of the city.

First we go to the south part and stop at Ramat Rachel, where there was much fighting during the 1948 war. We walk into the original dining room of this farm cooperative, which was used as a fort during the war. Because of its strategic importance and historic significance, the building now serves as both a military outpost and a sort of national shrine.

From the roof of this building we look across a no man's land of a few hundred yards to Trans Jordan. A little further away we see the small town of Bethlehem. The rather stupid soldier on guard objects to photography.

Reifenberg says that Jerusalem is just about the eastern limit of Terra Rossa on the hard limestone. It never is found, he says, on the soft limestone. To the east, in Trans Jordan, he says the soils are mainly Sierozem.



K-2097 May 3, 1952
Ramat Rachel. Mrs. Reifenberg, Prof. Reifenberg, Mrs. Richards, and Dr. Richards.



K-2099 May 3, 1952
Jerusalem, Hill of Evil Counsel. Looking
into Old City. Temple of Omar in distance.

We then drive to another high spot within the city near the frontier called Bar Aba Tar or the Hill of Evil Counsel. I try several photographs here.



K-2100 May 3, 1952
Jerusalem, Hill of Evil Counsel. Looking over the frontier. Note barbed wire in foreground and Arab soldier on housetop beneath.

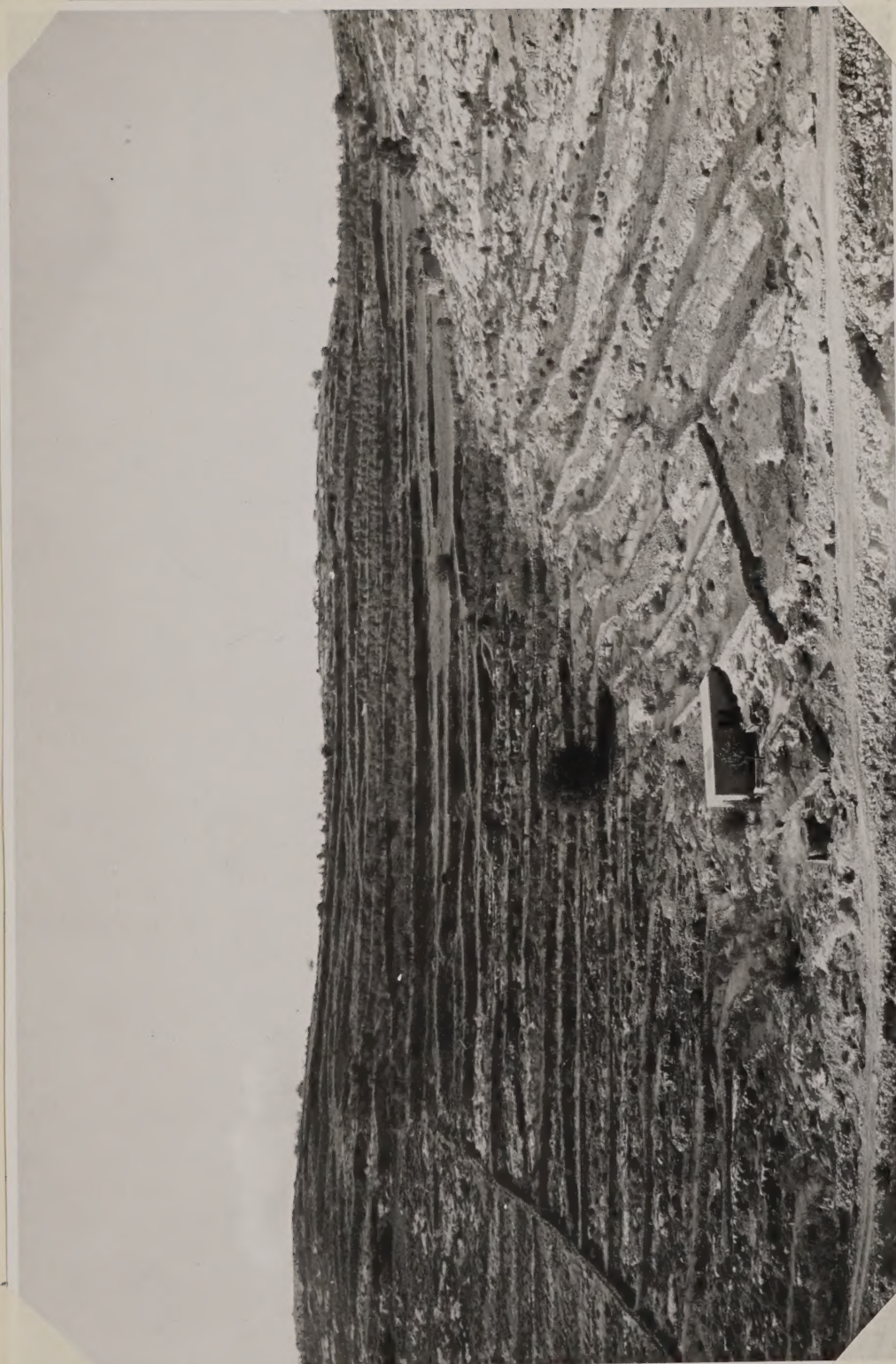
We then drive to another high spot within the city near the frontier called Der Abu Tor or the Hill of Evil Council. I try several photographs here, looking into the old city and some into the new city. Just a few yards away, across the frontier, stands an Arab guard on the next housetop. We chat a bit with a Jewish immigrant family from Egypt that occupies the house immediately next to the frontier and separated from it by rolls of barbed wire.

We return to the hotel about 1:00 p.m. for our lunch. Afterwards I go to my room for a little rest on this holy day. I am told that many of the Jewish residents are very strict and even regard smoking on the street on this day as offensive.

Professor Reifenberg had explained this morning that the water supply for Jerusalem is inadequate, due mainly to an inadequate supply of electricity for pumping. Most of the water comes through pipes from the coastal area. A good deal of this coastal area is occupied by old sand dunes, which are, of course, excellent for gathering the water. Yet, they have here in Jerusalem about 26 inches of annual rainfall. Most of this comes between the middle of October and the end of April, some of it as very hard showers.

In olden times the houses all had cisterns. I am told that it was the water in the cisterns that kept Jerusalem going during the 1948 war. Reifenberg says that the cost for blasting holes for cisterns and constructing them is very high. Yet, I believe it is a serious mistake to depend so exclusively on piped water from the coastal area near Tel-Aviv. I believe that the construction of cisterns, either below ground or above ground, should be strongly encouraged, perhaps through subsidies. I am sure that if I had a house in Jerusalem I should make a cistern in some way to take care of a garden. I noticed that there were very few gardens, partly because of no dependable water supply.

About 5:30 Dr. and Mrs. Sambursky and Mr. Mouschine called to take some of us for another drive to the west of the city. We stop near the outskirts and climb a little hill to Herzl's Tomb. Herzl was the founder of Zionism. A little further beyond, I see some fairly effective old terraces on lithosolic Terra Rossa. Near Ein Karim there are Arab families on the left and now some new settlements for immigrants, which are partly agricultural. We pause briefly in a part of Ein Karim called the Children's Village. Apparently there are some Arabs still left here and Russian Orthodox Catholics,



K-2101 May 3, 1952
Just west of Jerusalem. Old terraced lithosolic Terra Rossa.

K-2101 May 3, 1952
Just west of Jerusalem. Old terraced lithosolic Terra Rossa.

as well as Jewish people. I understood that many orphan children are cared for. This is a beautiful place with irrigated vegetation in the lowland and figs, apples, and other fruits on the terraced hills. We drive on and pass a French Catholic monastery near Suba. I try to take pictures here including groves of olives on steeply sloping

lithosolic Terra Rossa

a great contrast between

groves and some of the

forested or cultivated

goats for many years.

We drive back to

stop for tea and then for our monastery. It is very beautiful.

We take us back to the monastery. It is very beautiful. evening. I again decide to have dinner and take two oranges for a hot-time lunch.

arranges for a hot-time lunch.

I read the report

had.



K-2102 May 3, 1952

Near Suba. French monastery on lithosolic Terra Rossa.



K-2103 May 3, 1952

Just west of Jerusalem. Olives on terraced lithosolic Terra Rossa.

as well as Jewish people. I understand that many orphan children are cared for. This is a beautiful place with irrigated vegetables in the lowland and figs, apples, and other fruits on the terraced hills. We drive on and pass a French Catholic monastery near Suba. I try to take pictures here including groves of olives on steeply sloping lithosolic Terra Rossa with old stone terraces. There is a great contrast between reasonably-well, cared-for olive groves and some of the nearly barren hills that were formerly forested or cultivated and then badly overgrazed by Arab goats for many years.

We drive back into the city in late afternoon and stop for tea chez Professor Sambursky. It is very pleasant. He takes us back to our hotel a little after 8 in the evening. I again decide to miss dinner and take two oranges for a bed-time lunch.

I read the printed proof of my lecture and go to bed.

LA JERUSALEN DE HOY



- CIUDAD VIEJA
- CIUDAD NUEVA
- ✝ SANTOS LUGARES CRISTIANOS
- SANTOS LUGARES MUSULMANOS
- SANTOS LUGARES JUDIOS
- ★ HOSPITALES Y SERVICIOS DE SALUBRIDAD
- INDUSTRIA Y COMERCIO
- ESCUELAS
- ACTIVIDADES CULTURALES
- ✓ SERVICIOS PUBLICOS
- COMUNICACIONES
- LINEAS DE DEMARCACION
- JARDINES PUBLICOS Y CAMPOS DE JUEGO

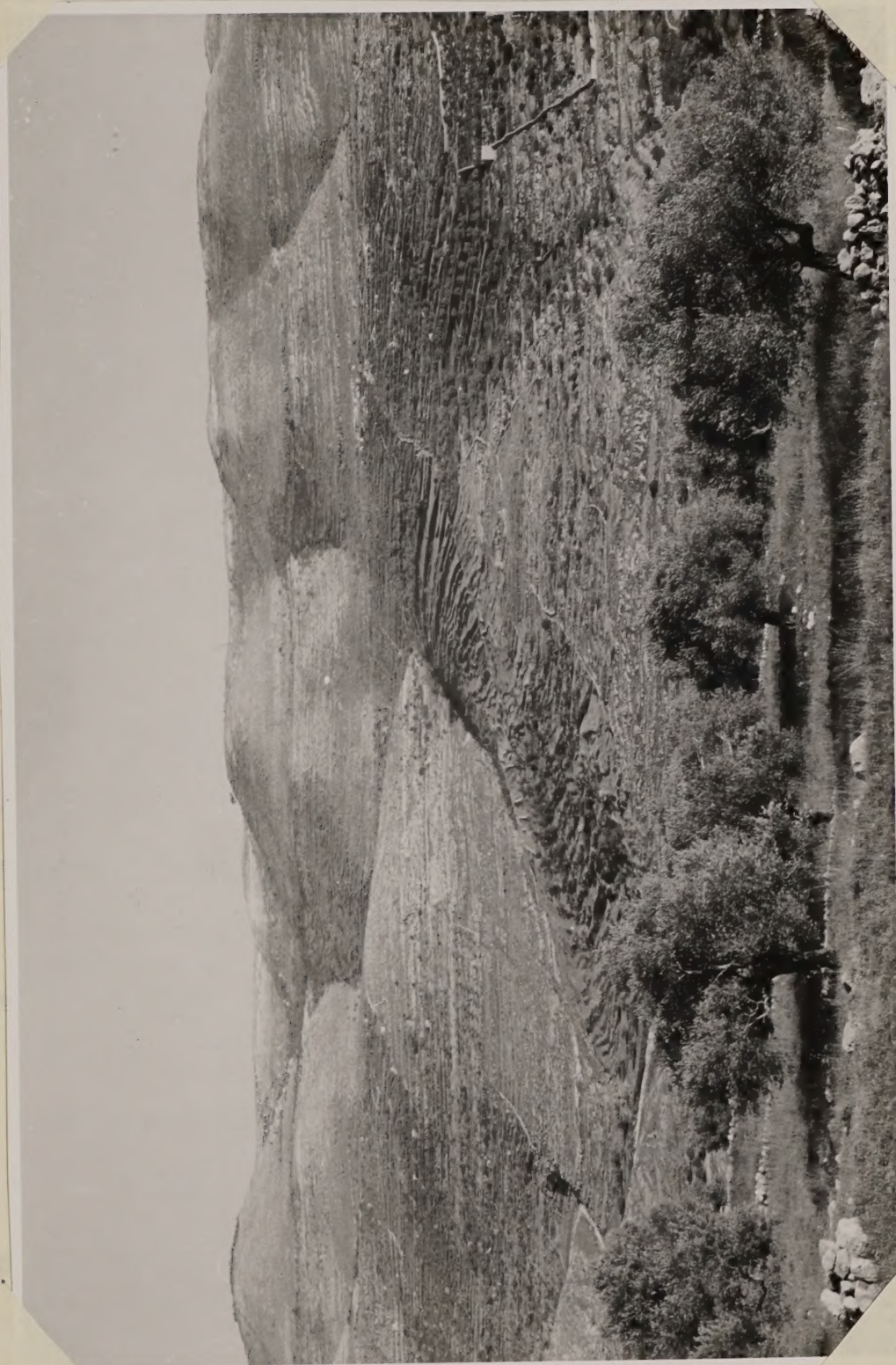
A. GAMES.

JERUSALEN - PARTE INTEGRAL DE ISRAEL



PLAN PARA EL DESARROLLO DE JERUSALEN

- CIUDAD VIEJA
- CIUDAD NUEVA
- NUEVA ZONA RESIDENCIAL
- INDUSTRIA
- CENTRO COMERCIAL
- HAKIRIA
- MONUMENTO A HERTZL
- ZONA DE ESTABLECIMIENTO AGRICOLA
- CARRETERA DE CIRCUNVOLUCION EXTER.
- CARRETERA DE CIRCUNVOLUCION INTER.
- RESERVAS DE AGUA
- ESPACIOS ABIERTOS Y CINTURON VERDE



K-2104 May 3, 1952
Just west of Jerusalem. Lithosolic Terra Rossa; olives in foreground.

May 4

I am up early in a cool sunny morning and work on the Symposium material until Professor Reifenberg calls at my hotel about 10:00 a.m. I go with him in his jeep to the soil laboratory of the university. Like other departments of Hebrew University, this one has temporary quarters. It is a great pity that the buildings and equipment of Hebrew University, together with their fine laboratories and hospital, are just rotting away a few hundred yards over the frontier of Trans Jordan. According to the armistice terms, the Israelites were supposed to have access to it, but this has never been arranged. One or two members of the university go up to the buildings at infrequent intervals with officials of the United Nations; but they are not permitted to take anything away. This temporary laboratory is very near the frontier where a narrow no man's land of bombed buildings separates the two Jerusalems.

I met Mr. Dan Yaalon and Mr. S. J. Buckwald, who are to take me out in the country. Yaalon is working mainly on soil salinity now. Buckwald was born in Canada and was formerly on the staff at the University of Manitoba and at North Dakota State. He is studying silicic acid in soils. After a brief stop at the post office for stamps we go out of Jerusalem to the northwest along the main road to Tel-Aviv.

A few miles out we stop at a kibbutz -- Kiriat-Be'er -- that started as a communal settlement some 32 years ago. Although the original founders came mostly from Europe, the present members have come from many countries. I met, for example, a young man from Chicago. Chaim Davis, who has been living in the kibbutz for three years. He finished high school here and works on the farm.

First we call

relatively young

is Chaim Milinski.

had some technical

is a mixed farm

will be mainly

in cultivation and



very steep slopes. All the steep slopes

seem hopeless. Jerusalem. Looking into narrow

no-man's-land between Jerusalem-Israel

and Jerusalem-Trans Jordan.

be placed into terraces, partly to control runoff and erosion

and partly to serve as elongated stone piles, and good soil

developed for vines and fruit. The steeper slopes are grad-

ually being reforested. Except for some sparse grain grown

on a field belonging to this kibbutz near Be'er is the coastal

plain. Food for cows and poultry is purchased and prepared by

a mixing plant on the farm. The cattle are maintained in a

dry lot. They are also looking, poor-kind of feed. They

A few miles out we stop at a kibbutz -- Kiriat-Anavim -- that started as a communal settlement some 32 years ago. Although the original founders came mostly from Russia, the present members have come from many countries. I meet, for example, a young man from Chicago, Chim Navis, who has been living in the kibbutz for three years. He finished high school here and works on the farm.

First we call at the secretariat and meet a pleasant, relatively young bookkeeper who shows us about. His name is Chaïm Kilinski. He came originally from Germany and has had some technical training in agriculture in Sweden. This is a mixed farm with fruit, dairy cows, and poultry. The soil is mainly lithosolic Terra Rossa and its normal associates in colluvial and alluvial positions, with Lithosol on the very steep slopes. At first glance all the stony slopes seem hopeless. But with careful planning, the stones may be placed into terraces, partly to control runoff and erosion and partly to serve as elongated stone piles, and good soil developed for vines and fruit. The stonier slopes are gradually being reforested. Except for some coarse grains grown on a field belonging to this kibbutz near Hulda in the coastal plain, feed for cows and poultry is purchased and prepared in a mixing plant on the farm. The cattle are maintained in a dry lot. They are nice looking, pure-bred Friesians. They



K-2107 May 4, 1952
Kiriati-Anavim. Part of dairy herd.



K-2108 May 4, 1952
Kiriati-Anavim. Background - 25 year
old pine forest; foreground - part of
chicken house.

have 150 milking cows, 70 calves, and 4 bulls. They have 9,000 laying hens and three to four thousand pullets. The hens are mostly Leghorns, but they have a few Suffolk -- a larger breed -- to cross with the Leghorns. They hatch their own chicks. The produce from these enterprises is marketed in Jerusalem.

It is amazing that pine trees do as well as they do on these very stony slopes. Of course, the limestone is cracked and the roots find their way into excellent Terra Rossa clayey soil within the cracks. From a planting about 25 years old, some commercial cutting has begun. I am told that since planting forest on this slope the water supply in wells in the low ground has steadily improved. Other hills are about to be planted to trees. New immigrants in the "transition camps" are commonly used for this work.

We walk among the buildings to inspect the cattle and poultry. Mr. Kilinski tells me a bit about their organization. They have 140 members and 120 children. Candidates and additional day laborers (used at the request of the government, although not strictly in accord with their ideals) would total 340 persons. Thus, this kibbutz classifies as a small one where everyone knows nearly everyone else personally.

Formerly, they could have only one room per family. But now that the kibbutz is doing better financially, each family requiring them has two rooms and a cottage, one for the parents and one for the children. The children are cared for in the general nursery until they are three years old. Thus, up to this age they don't spend much time with their parents; but afterwards they are with them until about thirteen years of age. Then they have their own rooms, perhaps two or three together in a room. They normally become full members at 18 years of age.

After school each boy and girl has two years of military service. The girls have some basic military training and are then assigned to clerical or communication work or to agricultural work, especially in the frontier kibbutzim.

New settlers wishing to join the kibbutz have a year's probation as candidates. They may or may not be Jewish.

No one is made to work except by the force of public opinion. The committee for work, however, may have discussions with any lazy ones.

What people have in their rooms is regarded as their personal property. This includes furniture made in the kibbutz and the things they may have brought with them such as books and objects d'art. A committee sees to it

Formerly, they could have only one room per family. But now that the kibbutz is doing better financially, each family requiring them has two rooms and a cottage, one for the parents and one for the children. The children are cared for in the general nursery until they are three years old. Then, up to this age they don't spend much time with their parents; but afterwards they are with them until about thirteen years of age. Then they have their own rooms, perhaps two or three together in a room. They normally become full members at 18 years of age.

After school each boy and girl has two years of military service. The girls have some basic military training and are then assigned to clerical or communication work or to agricultural work, especially in the frontier kibbutzim.

New settlers wishing to join the kibbutz have a year's probation as candidates. They may or may not be Jewish. No one is made to work except by the force of public opinion. The committee for work, however, may have discussions with any Jassy ones.

What people have in their rooms is regarded as their personal property. This includes furniture made in the kibbutz and the things they may have brought with them such as books and objects d'art. A committee sees to it

that the standards in the rooms and cottages are as good as possible. Six years ago members were satisfied with the central radio and there were no individual sets. Since then, the kibbutz has been able to buy individual radios for all but five families. Much of the tailoring, but not all, is done within the kibbutz. Of course in these communal settlements everyone shares alike from the common store. As much as possible is done within the kibbutz itself. Those who need to travel are given such money as they require for expenses.

Everyone eats in the central dining hall. The kitchen is very well equipped with steam for cooking and other conveniences. People take turns for kitchen and dining room duty. (In fact, I heard a story about important visitors coming to one kibbutz when it was the turn of the Minister of Agriculture, a cabinet member, but also a member of the kibbutz, to wait on tables, which he did!!) The dining hall has many tables to accommodate six people. These tables are arranged on either side of a large room. On entering, an individual must take the next place in order to make serving easier.

We go in for lunch. It is a fairly heavy lunch for people who are working hard. I have mashed potatoes, beets,

that the standards in the rooms and cottages are as good as possible. Six years ago members were satisfied with the central radio and there were no individual sets. Since then, the kibbutz has been able to buy individual radios for all but five families. Much of the talking, but not all, is done within the kibbutz. Of course in these communal settlements everyone shares alike from the common store. As much as possible is done within the kibbutz itself. Those who need to travel are given such money as they require for expenses.

Everyone eats in the central dining hall. The kitchen is very well equipped with stoves for cooking and other conveniences. People take turns for kitchen and dining room duty. (In fact, I heard a story about important visitors coming to one kibbutz when it was the turn of the Minister of Agriculture, a cabinet member, but also a member of the kibbutz, to wait on tables, which he did!!) The dining hall has many tables to accommodate six people. These tables are arranged on either side of a large room. On entering, an individual must take the next place in order to make serving easier.

We go in for lunch. It is a fairly heavy lunch for people who are working hard. I have mashed potatoes, beans,

fish, beans, soup, and an orange. Apparently this order of serving is a relic from the old days of hard labor when each man ate his share of solid food, which might be quite small, and then filled up on soup.

They now have
When the kibbutz
how to proceed.
kibbutz became the
years. They have
planting of 28
has been helpful



Although the hard limestone is cracked and permeable, the clay holds water. Although some crops can be grown without irrigation, they have recently begun to use some supplementary watering in the summer.

Prior to planting
into walled terraces
they did not know
on the contour, a
getting plants.
to 12 percent slope



Requirement partly determines the distance between terraces.

None of this work
Kiriat-Anavim. Grapes on terraced
Terra Rossa.

fish, beans, soup, and an orange. Apparently this order of serving is a relict from the old days of hard times when each one ate his share of solid food, which might be quite small, and then filled up on soup.

They now have the third planting of fruit trees and vines. When the kibbutz first began, the members didn't know quite how to proceed. With the help of the Jewish Agency, this kibbutz became then a sort of testing station for several years. They have only two fruit trees left of their first planting of 28 years ago. Much of the experience gained here has been helpful to other kibbutzim on Terra Rossa soils.

Although the hard limestone is cracked and permeable, the clay holds water well. Even the stone itself holds some water. Although some fruits can be grown without irrigation, they have recently begun to use some supplementary watering in the summer.

Prior to planting, the stones are removed from the soil into walled terraces now placed on the contour. At first they did not know how to prepare the soil, failed to plant on the contour, and failed to keep out weeds and other competing plants. In preparing the soil, they now allow up to 12 percent slope between the terraces, but no more. This requirement partly determines the distance between terraces. More of this work is now done with heavy tractors, bulldozers,

and pneumatic hammers to break up the big stones and ledges. Often the natural ledge makes the foundations for the terraces.

After lunch we go out with the horticulturalist on the kibbutz, one of its farmers, to look at the vines. They grow a rather late sort of very early red table grapes on the market after those from the coastal plain have passed. On the way I saw some nice flower beds about the buildings. The barnyards lay out.

The rows of 1-3/4 meters apart a tractor.

Peaches are plain; the horticulturalist



have some Elberta peaches. Apples can be grown.

We drive in Kiriat-Anavim. Recently reclaimed and terraced lithosolic Terra Rossa. Plums just planted. It requires about 100 work

days to prepare one acre of this soil. The bulldozer marks the terrace and a roller covers the small slopes. A pneumatic hammer is used for the big ones. Finally the terraces are built up by hand.

The fruit trees, here mostly plums and peaches, are set in holes with 60 centimeters deep. The grapes are set 15 centimeters deep. For this new plantation, an irrigation

and pneumatic hammers to break up the big stones and ledges. Often the natural ledges make the foundations for the terraces.

After lunch we go out with the horticulturist on the kibbutz, one of its founders, to look at the vines. They grow a rather late sort so they may put table grapes on the market after those from the coastal plain have passed. On the way I see some nice flower beds about the buildings. The barnyards have some very bad weed patches crying to be cut.

The rows of grapes are $2\frac{3}{4}$ meters apart, with plants $1\frac{3}{4}$ meters apart in the rows. They are cultivated with a tractor.

Peaches are said to do better here than in the coastal plain; the horticulturist claims 10 tons per acre. They have some Elberta peaches. Apples can be grown.

We drive in the jeep over some very stony Terra Rossa to a new clearing and planting. It requires about 200 work days to prepare one acre of this soil. The bulldozer marks the terrace and a rooter moves the small stones. A compressor or pneumatic hammer is used for the big ones. Finally the terraces are built up by hand.

The fruit trees, here mostly plums and peaches, are set in holes made 60 centimeters deep. The grapes are set 45 centimeters deep. For this new planting, an irrigation



K-2112 May 4, 1952
Kiriat-Anavim. Recently reclaimed and terraced lithosolic Terra Rossa with peaches.

system is being developed. I took several photographs of this development, at least I wrote several films, and we leave.

We are back on the main road to Tel-Aviv. I pass the Arab village of Ein Karem in Israel and help go on down the road to Jerusalem by an settlement for the Arabs in the Judean Desert of Ein Karem.



We stop for K-2113 May 4, 1952. He tells me about his work with the Reclaiming lithosolic Terra Rossa. New work in foreground. I photograph interpretation. I urge him to get a release of the photographs for publication.

When I return have arrived from a roommate. Forth Albert transferred about 8, and after



K-2114 May 4, 1952
General view of part of headquarters. Lithosolic Terra Rossa in foreground; 25 year old planted forest right background.

system is being installed. I take several photographs of this development, at least I expose several films, and we leave.

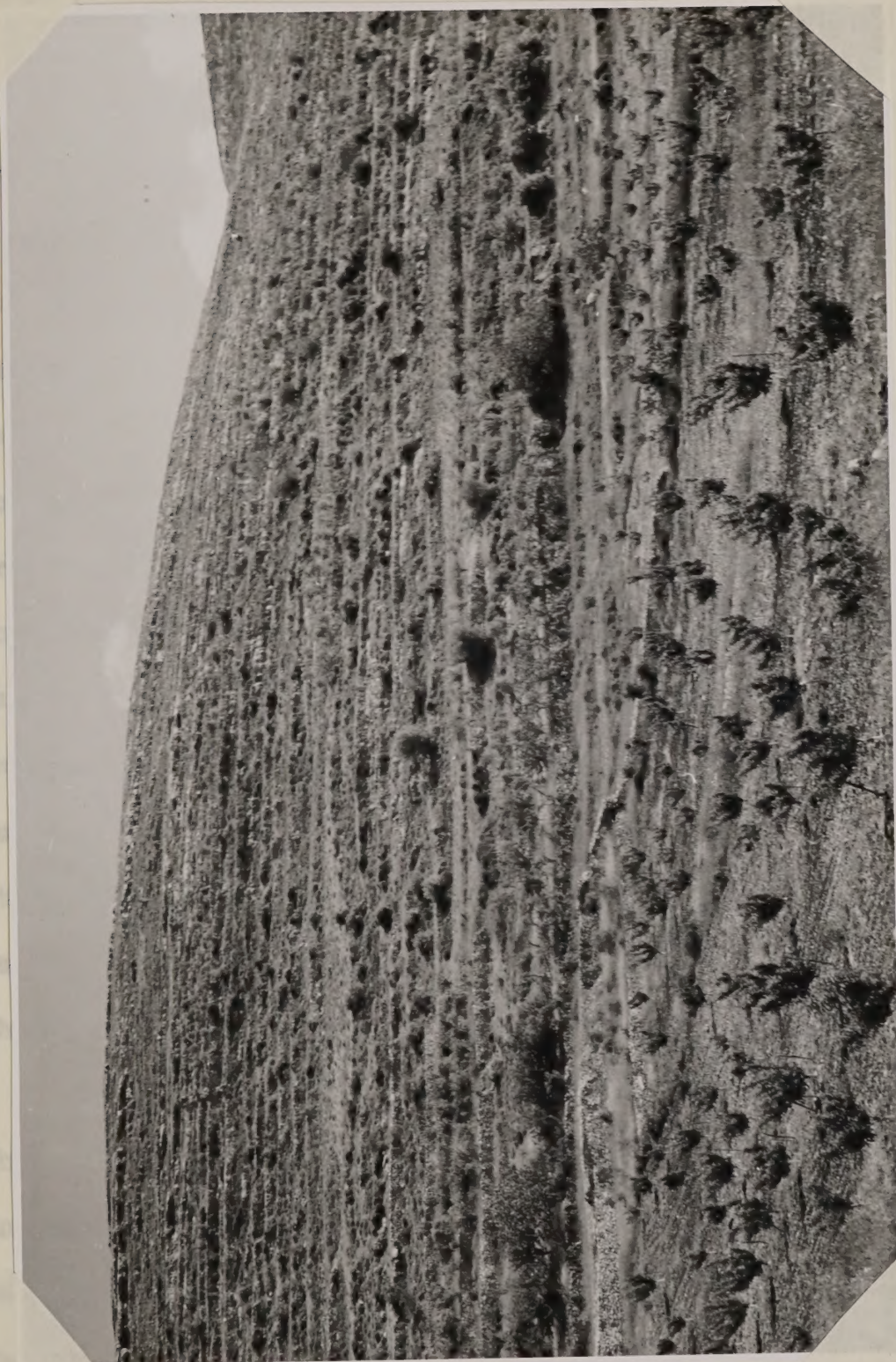
We are back again on the main road to Tel-Aviv. Again I pass the Arab village of Abu Gosh. These Arabs remained in Israel and helped the Jews against the Arab Legion. We go on down the road to the cutoff near Latrun and return to Jerusalem by another road further south. We pass a new settlement for the Yemenites and some reclamation of Terra Rossa in the Judean Hills. We return to the city by way of Ein Karim.

We stop for tea chez Reifenberg. He tells me about his work with the British Army on aerial photograph interpretation. I urge him to get a release of the photographs for publication.

When I return to the hotel I find that other guests have arrived from various countries and that I must have a roommate. Fortunately, I am able to get my old friend Aubert transferred to my room. We have dinner together about 8, and after a little chit-chat I go to bed.



K-2115 May 4, 1952
Near Suba. Reclaiming lithosolic Terra
Rossa



K-2116 May 4, 1952
Near Suba and near Ein Karim. Reclaimed terraced Terra Rossa in foreground;
old lithosolic Terra Rossa in background.

May 5

After breakfast Miss Valero comes to the hotel and discusses arrangements for return transport. She schedules me to leave Israel May 16 and to leave London May 27.

Then Mr. Yaalon and Dr. M. Rim come to the hotel to take Aubert and me to the agricultural experiment station at Rehovot. We drive out along the same road to Tel-Aviv rather rapidly. We stop for a moment to look at new cottages and gardens for immigrants near Ramle. These are on red sandy soils developed from calcareous sandstones that were formed from old dunes. Quite a bit of this soil is used for citrus. One sees a good many citrus plantings now in rather bad shape because of failures of the water supply during the 1948 war. We arrive at the experiment station and find that through some error the Director, Professor Ravikovitz, did not know that we were coming today. This is a great pity but he is away in the Negev.

I meet Professor Oppenheimer, an expert on citrus. They are studying irrigation and other problems of management. An important immediate problem is the one of trying to save many of the old plantations injured by lack of irrigation during the war by pruning. They have the usual chlorosis problems from deficiencies in zinc, iron, and nitrogen and from excess salts.

We met Mr. J. Schellinger, who works in the sales department, but who does not have any work about any of the projects.

He tells us that they are making soil surveys of some old and some new settlements. There were 100,000 in 1900, 200,000 in 1920, 300,000 in 1940, and now 400,000. I saw a soil map of part of the Valley. It is a combination of a luxury home, a "second home," and a "third home." It is a problem they say "chlorine" and "salt" figure is an



K-2117 May 5, 1952
Near Ramle. Suburban garden homes.

We are told that the problem is not going to be very small. It is not only a problem of water, but also of soil. The problem is a question of how to use water on high-line hills. They are concerned with the utilization of moving sand dunes and the utilization of sand as a soil amendment. We are shown pictures of various success with green manure on sand dunes. Barren flower (7. almond), fertilized in the usual way -- with about 50 kilograms of a mixed (7) fertilizer per acre -- gives good

We meet Mr. K. Schallinger, who works in the soils department, but who does not know very much about many of the projects.

He tells us that they are making soil surveys of some old and some new settlements. Some maps are on a scale 1:100,000 and some at 1:20,000. I see a soil map of part of the Negev. This one is quite confused. The legend is a combination of geological terms and soil color and soil texture terms. Examples are "red sandy soils," inland sand dunes," and "loess soils." In some places where salt is a problem they are producing single characteristic maps, say "chlorine content" or "salt." On this last one, the salt figure is an average of seven layers of 30 centimeters each. I am afraid these maps are not going to be very useful.

We are told that some work is underway in soil microbiology, in soil physics, and in soil chemistry. One of their important problems is a question of how to use salty water on high-lime soils. They are concerned with the reclamation of moving sand dunes and the utilization of peat as a soil amendment. We are shown pictures of very good success with green manures on sand dunes. Berseem clover (*T. alexandrinum*), fertilized in the normal way -- with about 60 kilograms of a mixed (?) fertilizer per acre -- gives good

results. So does alfalfa. After treatment, this soil requires less water for irrigation. They find eucalyptus trees useful for windbreaks.^{1/}

They are concerned with ways to impregnate the soil in basins to hold water for irrigation. They have had success with gypsum and loess on the sandy soils.

Something is said about the peat in the northeast part of the country near Lake Tiberias. It is said that this is a "low moor" peat derived mainly from papyrus and reeds. There is an upper layer of from 1 to 7 meters of the peat and then several meters of alluvium and deep peat beneath. The surface layer of peat has 18 to 30% ash. An undetermined part of this is outside mineral material. In order to transport the material for use as a soil conditioner, it is said that the peat must be dried. But it dries down to a hard mass that is essentially irreversible. An attempt is being made to find ways to treat and dry the peat so it will reabsorb water. The existing exchangeable bases are largely calcium. By exchanging the calcium for ammonium, the peat disperses. When dried, this treated peat will reabsorb about 80 percent of the original water. This treated

^{1/} Added later: Many of the details of the work here were explained more adequately by the director on another visit May 7th.

peat has a total of about 5 percent nitrogen, one-half of which is added by the treatment. The added nitrogen is available and the treatment is said to increase the availability of the original nitrogen. They are just now preparing some test materials to use on crops. They hope to solve this problem of how to use the peat before the marshes are drained according to a proposed scheme; otherwise the peat will be lost.

As we walk through the building I see another soil map of the upper Galilee region. Soil samples were collected on a grid basis with borings $\frac{1}{2}$ kilometer apart. The grid is laid out on a scale of 1:20,000. After the analyses are made, the laboratory man colors around each soil sample location and attempts to make some sort of map. This is unsatisfactory.

The legend includes Terra Rossa, Alluvial soil, calcareous soils (mountain marls), mixtures of limestone, basalt, etc. The mountain marl is simply the lithosolic end of the Rendzina from soft limestone.

I go over to the Department of Agricultural Economics for a brief discussion with J. Oppenheimer (a brother of the citrus expert) and J. Kadmon-Raitzyne. I first raise the question with these gentlemen about any studies they may have made on the relative efficiency of the various

kinds of farms in Israel. I referred to the budget analyses explained in Dr. Black's book. Although they said they were familiar with the book, I am afraid it has not stimulated them to do much of this kind of farm management research. They agreed with my assertion that it would be highly desirable to have comparisons of individual farms, cooperative farms, and kibbutzim in order to estimate their relative efficiency and the present efficiency of each in relation to what it could be.

I am told by Oppenheimer that there is not so much difference economically between the various systems as many think. He feels that there are far greater variations among individual units within each group. He does say that a small farm is becoming less successful, partly because there are fewer people to do the heavy tiresome work, such as that required for a dairy.

I get a long lecture that I find difficult to comprehend completely. I am told that the kibbutz is probably not successful where the enterprise includes a lot of field crops, including irrigated crops. The deciding factor, I am told, would be the percentage of labor expenses. It is said that fodder crops require very much work. I am not convinced of this reason.

I am told that the kibbutz is generally successful with intensive dairying and poultry partly because of the

opportunity to concentrate skills. This seems reasonable.

Then I am told that the kibbutz does not do so well with vegetables where a lot of work is required. It is felt that in the kibbutz there is too little relationship between the work of individuals and the income, in contrast to the Russian system. It is claimed that the kibbutzim worked fairly well when the settlers were carefully selected. It is said that the more recently established ones are less successful. Young people from Europe are said not to be enthusiastic for the kibbutz. I am told that some kibbutzim were too small for the available working force. I gather that Mr. Oppenheimer feels that garden-farms, organized in cooperatives, have an important place in Israel.

I take a little look at the library and the flower gardens and then go to lunch with my hosts in the station lunch room.

After a pleasant lunch at the station, we drive a way south and visit a large kibbutz -- Givat Brenner. We call at the secretariat and are shown about by Mr. S. Ben-Adam, a slightly crippled member originally from Canada, who divides his time between bookkeeping work and teaching in the school.

This kibbutz began in 1928. About one-half the members are from Germany. Many are from Lithuania; but altogether

I am told that there are now over 200 kibbutzim in Israel (elsewhere I had been given a larger figure). Many of the early ones failed for numerous reasons. Some were too small. Some were too far from the city.



K-2118 May 5, 1952
Givat Brenner. Ordinary member's
apartment.

members have come from some 36 countries. From the top of one of the cultural buildings, I can look one way and see the Mediterranean and look the other way over the frontier into Trans Jordan.

I am told that there are now some 200 kibbutzim in Israel (elsewhere I had been given a larger figure). Many of the early ones failed for numerous reasons. Some were too small. Some split because of political or religious differences. I am greatly impressed with the willingness to work here and the far less attention to orthodox religious forms than among the sects in the city of Jerusalem.

This is a large kibbutz -- too large for each person to know all the others. To some this is a violation of the communal ideals. On the other hand, it makes possible the development of many more specialized interests and hobbies. One can find a congenial group for music, for dramatics, for chess, or for almost any other interest or skill. My guide explains that the large kibbutz is stronger economically by reason of greater diversification of enterprises. Here they now have 669 members, 70 candidates, 705 of their own children, 153 outside children, mostly orphans, and about 150 day laborers -- somewhat over 1,700 altogether. Here again, the day laborers are being employed at the request of the government, although

such employment is not consistent with the basic principles of the kibbutz. (Such employment seems to me to set a bad precedent that might later give the kibbutz some of the evils of monopoly). The day laborers, largely new immigrants in transition camps, do not live in the kibbutz. Besides these people, the kibbutz has a hired physician and a few hired school teachers.

It is explained that this kibbutz is one of a federation. I understand that there are about four federations, not counting one small Communist kibbutz. No one known to be a Communist is permitted at Givat Brenner. Two or three potential members have been expelled for this reason; but only one for laziness! The General Federation of Labor retains a 51% interest in the property. Thus, it would not be possible for the kibbutz to decide to dissolve and distribute the property among the members.

I am told that all members must be Zionist but not necessarily "religious" Jews or even Jewish at all. Each must belong to the labor organization, and each must be a practicing Socialist. The federation to which this kibbutz belongs has an immigration selection committee and many new immigrants are temporarily assigned to some kibbutz where it seems that they may fit in well. Other candidates are suggested by friends who are already members. Prospective members are first interviewed for their general fitness and then given a medical examination before

acceptance as candidates. For the first three days they stay on the kibbutz as guests, without working, to get acquainted with the place and to be sure that they want to go ahead as candidates. Then for a month they have a status as "working guests." After acceptance as candidates, they normally have that status for a year with all responsibilities and privileges of membership except for voting and holding office. A special committee of the kibbutz recommends candidates for full membership. These lists are posted in the dining hall where any member may observe them. The names are later voted on in a general assembly. Only rarely does a candidate fail of election to full membership. Occasionally one is elected to membership before a full year as candidate so he may be used on a committee assignment for which he may have special talent. During the period of his candidacy a person may attend the assembly meetings and may speak freely.

My guide explains that the assembly of all members is pure democracy. Anyone may speak as long as he wants to at the weekly meetings. All authority is reserved for the assembly. Officers and committees do not have delegated authority, but act as they are directed by the

acceptance as candidates. For the first three days they stay on the kibbutz as guests, without working, to get acquainted with the place and to be sure that they want to go ahead as candidates. Then for a month they have a status as "working guests." After acceptance as candidates, they normally have that status for a year with all responsibilities and privileges of membership except for voting and holding office. A special committee of the kibbutz recommends candidates for full membership. These lists are posted in the dining hall where any member may observe them. The names are later voted on in a general assembly. Only rarely does a candidate fail of election to full membership. Occasionally one is elected to membership before a full year as candidate so he may be used on a committee assignment for which he may have special talent. During the period of his candidacy a person may attend the assembly meetings and may speak freely.

My guide explains that the assembly of all members is pure democracy. Anyone may speak as long as he wants to at the weekly meetings. All authority is reserved for the assembly. Officers and committees do not have delegated authority, but act as they are directed by the assembly.

assembly. Thus, no one resigns for "lack of confidence," as in the usual parliamentary system, since there is no delegation. All questions can come before the assembly. Of course, a great deal of the management is really done by the many committees. One committee assigns work, another selects the movies, one looks after the music, and so on through a very long list of activities.

In the assembly there can be no secret voting. Even ballots must be signed to be valid.

If a member is dissatisfied with a decision, however, he can appeal to the secretariat of the federation to which this kibbutz belongs, and finally to the Council of Honor of the General Federation of Labor.

I am told that they have some difficulty in getting women to take as much interest in the local management as men. To prevent the ratio becoming unbalanced, a minimum of women members are required on committees for them to be properly established to function officially. The general council has 70 members, of whom no less than 25 must be women.

The children attend school here. I am shown one of the new schools which is very fine indeed. After eleven years of age children have some small tasks. At thirteen years, they have one month of work and one month free of

lessons and work during the vacation period. Yet children are asked to work on special occasions besides, say to help for a few days during tomato harvest. Records are kept of all work by children, as well as by adults, and these records are said to be matters of considerable personal pride.

Children have a great deal of self government. They have their own newspaper. Teachers here are not permitted to be disciplinarians. They may use no force on the children. Although they may assign homework, the teachers may not keep children after school hours, partly because this might interfere with their other duties. Disputes come before a sort of children's court, usually before teachers, but sometimes before the children. Such courts of honor are usually avoided by individuals because of unpleasant publicity. The children have a few bicycles and operate a rationing system for their use. They are also obligated to help the new immigrants in many ways.

Members are normally allowed eight working days of leave. Women over 45 and men over 50 are allowed 12 days. Then once in three years members get 10 working days of additional leave, together with travelling expenses and pocket money. If they have relatives in other countries

who will pay their transport, arrangements are made for longer periods of leave to visit them.

In the last fiscal year, September to September, this kibbutz had a gross income of about 1,000,000 Israel pounds (at the present rate of exchange, one Israel pound is exchanged for \$1.40 U. S. money; but of course, one cannot translate the budgets directly into dollars for many reasons). During this period, their working days were distributed about as follows: 55% service, 34.8% productive labor, and 10.2% sick and holiday leave. Of course, the services include many local activities inside the kibbutz for laundry, clothing, furniture, food preparation, entertainment, teaching, and the like.

They have about 800 acres of land permanently assigned to them and cultivate 2,600 acres more on a temporary basis. It appears to me that the soils are mainly undulating "red sandy soils" on the coastal plain and Alluvials. The soil is used mainly for fruits and vegetables, including quite a bit of citrus, mostly oranges. (Unfortunately I neglected to obtain figures for the dairy and poultry enterprises, but these are not large.) Agriculture accounts for about 40 percent of the income.

who will pay their transport, arrangements are made for longer periods of leave to visit them.

In the last fiscal year, September to September,

this kibbutz had a gross income of about 1,000,000

Israeli pounds (at the present rate of exchange, one

Israeli pound is exchanged for \$1.40 U. S. money; but

of course, one cannot translate the budgets directly

into dollars for many reasons). During this period,

their working days were distributed about as follows:

55% services, 24.8% productive labor, and 10.2% sick

and holiday leave. Of course, the services include

many local activities inside the kibbutz for laundry,

clothing, furniture, food preparation, entertainment,

teaching, and the like.

They have about 800 acres of land permanently

assigned to them and cultivate 2,000 acres more on a

temporary basis. It appears to me that the soils are

mainly undulating "red sandy soils" on the coastal plain

and Alfandala. The soil is used mainly for fruit and

vegetables, including quite a bit of citrus, mostly

oranges. (Unfortunately I neglected to obtain figures

for the dairy and poultry enterprises, but these are not

large.) Agriculture accounts for about 40 percent of the income.

Thus, about 60 percent of the income of this kibbutz comes from industries and services besides farming. Fruits and vegetables are canned, their own and those produced on other farms. They make furniture, of which about 80 percent is sold. Their machine shops are used 30 to 40 percent for work outside the kibbutz. They mold aluminum. They assemble machines made under their own patent. They maintain a fine resort hotel with a nice garden and park. Charges are $2\frac{1}{2}$ pounds Israel money per day per person for room and meals. They are said to be well booked in advance.

They make roughly 75 percent of their own clothing in the kibbutz. The individual chooses his clothing within limits established by the committee. The kibbutz has shares in a bakery cooperative, a bus cooperative, and other cooperatives.

Some members work outside the kibbutz as teachers, government workers or officials, artists, and the like. They get their expenses but their salary is paid into the kibbutz.

No distinctions are made in either prerequisites or income among members according to the total amount of work or kind of work they do. Each gets his meals in the general

dining hall. If ill he gets special food. A small kosher kitchen is maintained for the few who want that kind of food. Of course, each member receives full medical service as required. Each gets necessary clothing, laundry, and other services. Each member has allotments for books, for cultural expenses (theater and music in Tel-Aviv, and the like), for tobacco as required, and about 11 pounds Israel money per year as unassigned pocket money. If a member travels on official work of the kibbutz, he is allowed all normal expenses and the usual "extras" besides. Thus, members have no income taxes.

If a member leaves the kibbutz he is given no compensation or any share in the enterprise.

The proportion of the income of the kibbutz to be used for consumers' goods and services and the proportion to be put back in the new investment is a matter of great debate in the assembly. They are said now to invest about 20 to 30 percent of their income in productive enterprise. The assembly has passed a resolution to buy individual radios, but only when the price is low.

The only private property is that in individual rooms -- furniture, radio, books, and small things brought by the individual to the kibbutz.

Some children of the kibbutz are sent to the university with expenses, depending upon the child's wishes and teachers' recommendations, if passed by the general assembly. Thus, the general assembly might easily be debating the purchase of radios or bicycles as an alternative to university schooling for some of the children. We look at the library; it contains 20,000 books. They have one large and several small assembly rooms, a music room, and other rooms for art exhibits and the like. The big assembly room is now somewhat too small. The wooden chairs are very close together and they are not very comfortable (probably this fact helps reduce the length of meetings).

I look at some of the new cottages which appear quite nice. They hope to have two rooms available for each family that needs them. After tea in the dining room, I walk into the old section of cottages. These are not so nice as the new ones, but most have attractive lawns and flower gardens.

Our guide is an intelligent enthusiastic idealist for the kibbutz and easily meets every question. It seems to me that young people could fit in better than old ones. The lack of privacy with one's own family would be disagreeable to me; in fact, this phase of the kibbutz is shocking to my friend Aubert. I can understand that immigrants from the United States, Canada, Australia, New Zealand, and



K Is. 4.7 May 5, 1952
Givat Brenner. Old cottage area of Kibbutz.

other advanced countries with high standards of living might be disappointed. Still to many members from ghettos and concentration camps, this kind of life and opportunity must seem almost wonderful. So far, many members of the kibbutz have obviously been kept in high spirits by the finding of a new life and the beginning of a new country against heavy odds. Even now, the border with unfriendly people is near. Not long ago a member of this kibbutz was killed by an infiltrating Arab.

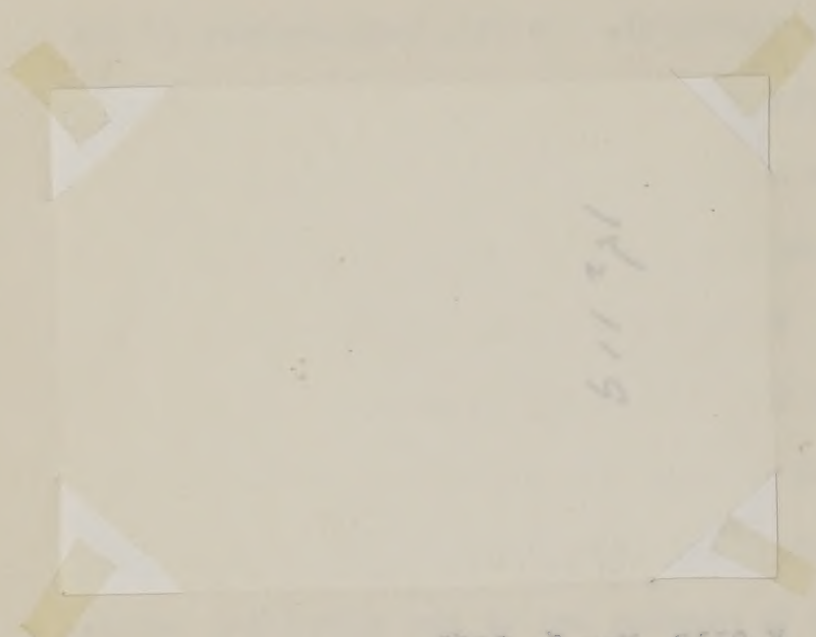
We leave the kibbutz about 5:30 and drive into Jerusalem. About 20 kilometers west of Jerusalem I stop for a while to examine one of the transition settlements for Yemenite Jews. This camp, called Kissalon, has been going for nearly two years. The people were brought from Yemen by plane in what was called "Operation magic carpet." As these people come to Israel they are very primitive indeed. Most of them are unaccustomed to European food and the use of ordinary dining room utensils. Many of them have held on to the old religious forms. A large part of the young men have characteristic curls in front of their ears from their temples. It takes a good deal of effort to educate these people and raise their standards. Although most of the young men can read, few of the women have had any education.



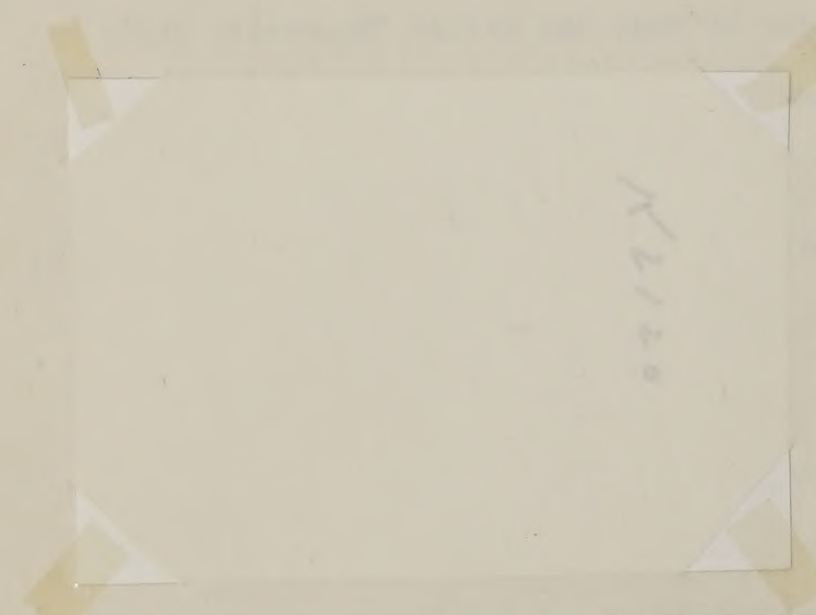
K-2119 May 5, 1952
Kissalon. Recent Yemenite immigrants.



K-2120 May 5, 1952
Kissalon. Yemenite woman in doorway of temporary aluminum house.



K-2119 May 5, 1952
Kassalon. Recent Yemenite immigrants.



K-2120 May 5, 1952
Kassalon. Yemenite woman in doorway of temporary aluminum house.

At this camp the people live in small aluminum cabins. I should think it would be very hot in them, although I am told that these are much better than tents. (There are still quite a few transition camps with only tents). The Jewish Agency has furnished individuals with some blankets, beds, and other necessities. I notice here that the chickens run about the place and actually occupy some of the beds. The people are employed for work on reforestation and various kinds of construction, especially highways.

It is late as we come into Jerusalem, and I am very tired after this long day in a jeep. We are back in the hotel at 7:30, and I hope to take it a bit easier tomorrow.

Professor Even Ari on the street who tells us that cameras are hard to come by in Jerusalem and that he will loan us one. Most of the shops are small. Many of them deal in silver and other objects d'art, books, toys, and leather goods. I see one Russian book shop, which seems to have several customers, with both propaganda books and technical books.

In the evening several of us are invited to the home of Professor and Mrs. Even Ari. I have a long conversation with the author of Man against the desert — Mr. Ritchie Calder.

At this camp the people live in small aluminum cabins.

I should think it would be very hot in them, although I am told that these are much better than tents. (There are still quite a few transition camps with only tents). The Jewish Agency has furnished individuals with some blankets, beds, and other necessities. I notice here that the chickens run about the place and actually occupy some of the beds. The people are employed for work on reforestation and various kinds of construction, especially highways.

It is late as we come into Jerusalem, and I am very tired after this long day in a jeep. We are back in the hotel at 7:30, and I hope to take it a bit easier tomorrow.

May 6

After breakfast with Aubert, I prepare answers to the various invitations for receptions and take them to the office of the Research Council. I use this opportunity to do a little shopping and end up by buying three Yemenite blouses for my women folk. I hope they are successful because these things are not cheap.

I return to the hotel and finish my correspondence and other writing. After lunch, I prepare my speech for the first session of the Symposium. After a brief nap, I take another walk in the city. I go into several shops looking for a cane, but I am unable to find one. I meet Professor Even Ari on the street who tells me that canes are hard to come by in Jerusalem and that he will loan me one. Most of the shops are small. Many of them deal in silver and other objects d'art, books, toys, and leather goods. I see one Russian book shop, which seems to have several customers, with both propaganda books and technical books.

In the evening several of us are invited to the home of Professor and Mrs. Even Ari. I have a long conversation with the author of Man against the desert -- Mr. Ritchie Calder.

May 6

After breakfast with Aubert, I prepare answers to the various invitations for receptions and take them to the office of the Research Council. I use this opportunity to do a little shopping and end up by buying three Yeminite plates for my women folk. I hope they are successful because these things are not cheap.

I return to the hotel and finish my correspondence and other writing. After lunch, I prepare my speech for the first session of the Symposium. After a brief nap, I take another walk in the city. I go into several shops looking for a cane, but I am unable to find one. I meet Professor Even Ari on the street who tells me that canes are hard to come by in Jerusalem and that he will loan me one. Most of the shops are small. Many of them deal in silver and other objects d'art, books, toys, and leather goods. I see one Russian book shop, which seems to have several customers, with both propaganda books and technical books.

In the evening several of us are invited to the home of Professor and Mrs. Even Ari. I have a long conversation with the author of Man against the Desert -- Mr. Ritchie Collier.

He is the science editor for the London "News Chronicle."

For some time he has been working on missions of the United Nations and WHO. He has just returned from a rather long and exhausting trip into southeast Asia for WHO.

I believe this party would have lasted indefinitely had I not insisted on leaving. Even so I don't get to bed until late.

He is the science editor for the London "News Chronicle".
For some time he has been working on missions of the United
Nations and WHO. He has just returned from a rather long
and exhausting trip into southeast Asia for WHO.

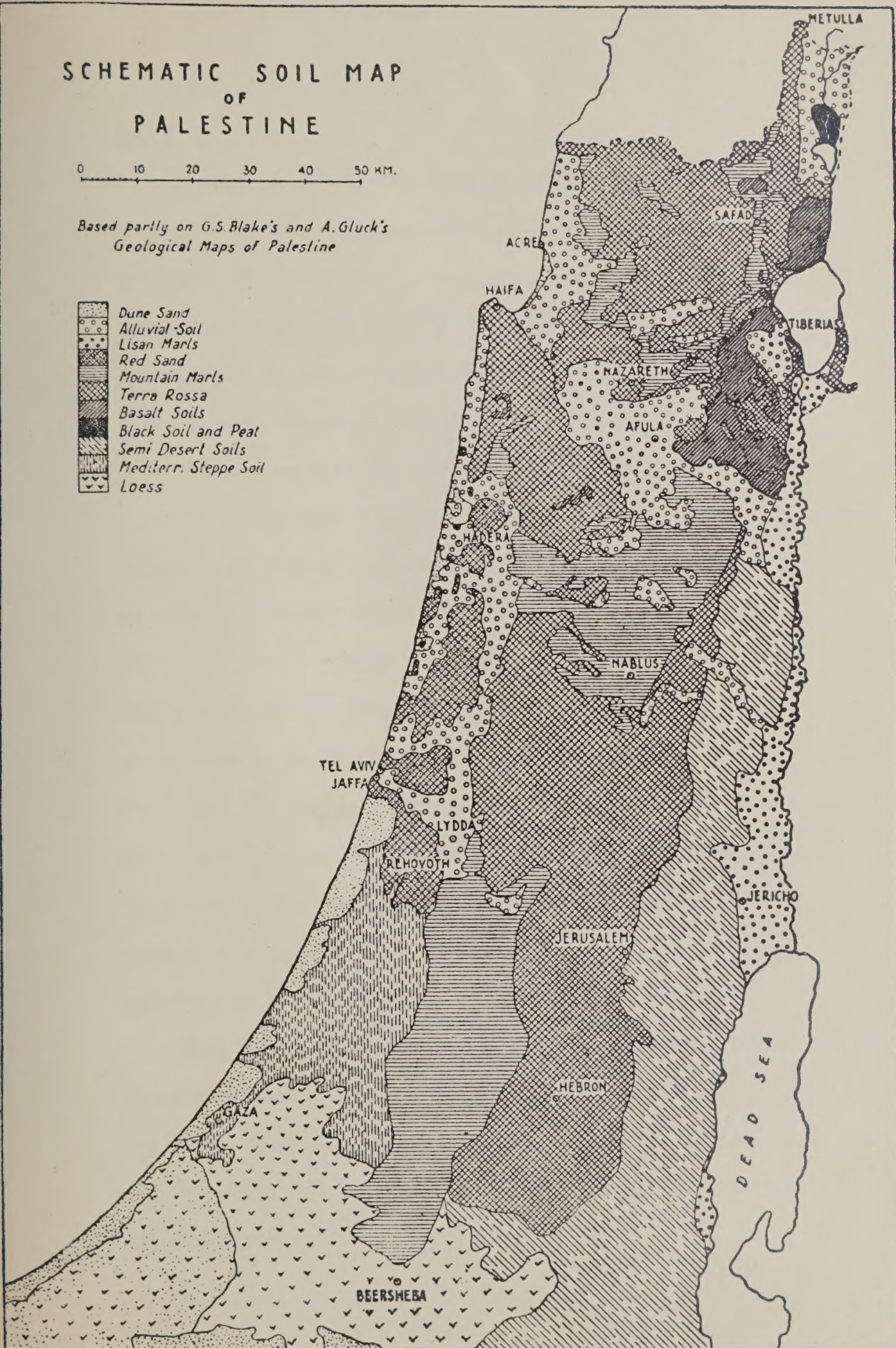
I believe this party would have lasted indefinitely
had I not insisted on leaving. Even so I don't get to
bed until late.

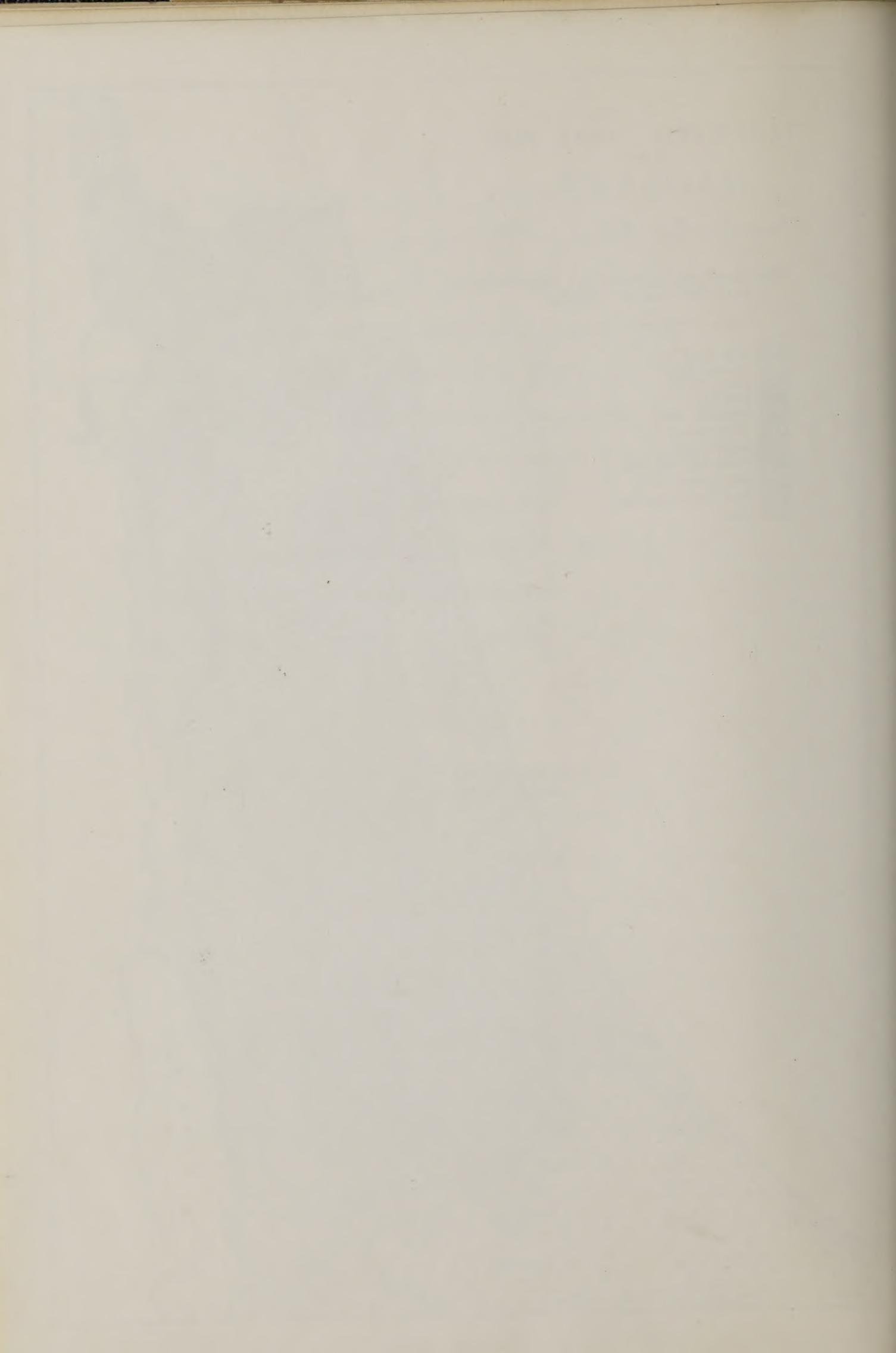
SCHEMATIC SOIL MAP OF PALESTINE

0 10 20 30 40 50 KM.

Based partly on G.S. Blake's and A. Gluck's
Geological Maps of Palestine

-  Dune Sand
-  Alluvial Soil
-  Lisan Marls
-  Red Sand
-  Mountain Marls
-  Terra Rossa
-  Basalt Soils
-  Black Soil and Peat
-  Semi Desert Soils
-  Mediterr. Steppe Soil
-  Loess





May 7

Professor Ravikovitz sends T. Hanon to our hotel with a jeep to bring Aubert and me to the experiment station at Rehovot. We leave at 8:55 a.m. and again drive out of Jerusalem on the main road to Tel-Aviv. I notice very few animals on any of the farms, except for occasional dairy herds. We reach the station about 10 a.m. and go into conference with Director Ravikovitz.

First, we have a general discussion of soil classification. We are told that most soils in Israel are calcareous with pH values between 7.0 and 8.2. He says that the greater the proportion of silty or colloidal lime, the greater the toxicity of excess chlorides. In the Jordan Valley some soils have 40 to 60 percent calcium carbonate in the clay fraction. We are told that a good correlation exists between chlorosis and the percentage of colloidal lime. The chlorosis is due mainly to iron deficiency and can be corrected with ferrous sulphate spray. Zinc deficiency appears mostly on the sandy soils along the coast.

They have had difficulty in fertilizing the calcareous soils with ammonium salts. They must be placed deeply in the soil. Many of the soils in the Jordan Valley are quite well supplied with phosphorus and most do not respond to phosphorus fertilizers.



K-2121 May 7, 1952
Rehovot. Ravikowitch and Aubert in front
of Ficus nitida.



K-2122 May 7, 1952
Rehovot. Soils laboratory.

K-2121 May 7, 1952
Rehovot. Raviakowitch and Aubert in front
of Picus nitida.

1/22/21

K-2122 May 7, 1952
Rehovot. Solis Laboratory.

1/22/21

The director tells us that the maximum rate of organic matter decomposition occurs in soils with two percent lime. At higher values the rate is slower. Aubert points out that this figure varies with the climate; and that at very high values for lime content, decomposition increases again.

The director emphasizes that the biggest problems he has now are high lime content and soil salinity. He has had trouble with the quick chemical test for plant nutrients that he has tried. He gets good results with plot technique, using lettuce as the test plant.

Soils from loess in the dry areas, he says, have little profile development. The dust now accumulating on these soils is quite like the existing soils. The greater the distance from the source, the greater both the clay and the lime. Much of the loess has come from saline deserts and contains both NaCl and CaSO_4 . In areas with less than 200 mm of rainfall the loess material is still salty.

We then speak of the red sandy soils like those here at the station. Old dunes were cemented with lime to a kind of pale yellow sandstone-kurkar. The director says that the grains seem to be coated loosely with

colloidal aluminum and iron. He says they leach down, leaving the surface lighter in color and giving a clayey B, even to a claypan or hardpan, locally called nazaz.^{1/}

Aubert and I go to lunch at the station with Director Ravikovitz. At lunch he tells me that there are some 170,000 Arabs still in Israel.

After lunch we take a very hurried trip to look at some of the "red sandy" soils. First we look at a much disturbed sandy type from a pit made in a mixed orchard on the station. (The Director says this is not quite typical!)

- | | | |
|-----------------|----------|---|
| A _p | 0-10" | Dark brown to brown (7.5YR 4/4) loamy sand. Lumpy in places but easily friable. Nearly structureless. |
| AB ₁ | 10-21" | Yellowish-red (5YR 5/6 to 4/6) loamy sand. Firm in place but easily friable. Perhaps slightly more clay than above. Nearly structureless. |
| AB _g | 29-41" | Very pale brown (10YR 7/3) when moist, nearly white when dry, structureless sand to loamy sand. |
| B (?) | 41-50" / | Yellowish-red (5YR 5/6 to 2.5YR 4/6) heavy sandy loam. Firm, sticky, and plastic. Nearly structureless. |

^{1/} Added later: Professor Reifenberg in his book on the Soils of Palestine questions this theory and postulates the possibility of lateral movement of iron and aluminum from the hills. It seems to me more likely that the textural B is due more to weathering in place and the claypan to this process along with gleying. The gleyed horizons may have active or fossil gley effects, or both.

Unhappily, the pit is much too shallow. This lower B horizon may go to another 20 or 30 inches the director says. The AB_g may be an old A_{2g} horizon.

The soil is gently undulating, with swells suggesting wind deposition. The rainfall is about 600 mm. Despite the gray layer of fossil gley, the director says the water table is not deep. He suggests that the AB_g is an ordinary eluviated horizon, but neither Aubert nor I can quite agree. He says this gray layer is often missing.

The soil is said to be lime free and to have a pH between 6.5 and 7.5. The director says that these "red sandy" soils vary widely in texture and are now degrading (presumably by leaching). The sandy members (without claypans) are the best soils in Israel for citrus and already there are many plantings of oranges on them.

A short distance away, perhaps a half mile, we look at another soil type of this group in a hastily prepared road cut.

Ap	0-10"	Yellowish-red (5YR 4/6) sandy loam, moderately mottled with dark brown from organic matter. Weak granular structure to massive. Brittle and friable.
----	-------	--

A ₂	10-20" <u>✓</u>	Yellowish-red (5YR 4/6) loam to sandy clay. Firm in place. Friable.
----------------	-----------------	---

- A₃ 20-25" Like the above but firm to hard.
Very slightly more red, faintly
mottled with shades.
- B₁ 25-32" (approx.) Reddish-brown (5YR 4/4 tending
toward 2.5YR 4/4) sandy loam. Some
mottling with shades. Hard. Massive
with faint vertical cracks.
- B₂ 32-54" / Dark red (10R 3/6) hard, massive,
sandy clay loam with some vertical
cracking when dry.

Unfortunately this profile is also poorly prepared.

The B₂ is said to be about three feet thick. In this
place the director says the B is approaching the pan or
nazaz layer.

The soil is undulating and appears to be well drained.
The director thinks that both leaching and the solidization
process are involved. He regards this soil as well "degraded."
Although some leaching is obvious, and likely there has
been some solidization, I believe clay formation in place
to be the largest factor.

We take a hurried look at a deep road cut, where the
surface two or three feet has been moved about, in order
to see an example of the nazaz layer.

Although undulating, the soil has poor internal drainage.
I suspect that the soil drainage fluctuates about as it does
in typical Ground-Water Laterite during formation. The soil
as a whole here suggests a Mediterranean Planosol, if there

is such a soil. The nazaz layer is more than two feet thick and lies here at some three feet or more below the original surface soil. It is medium gray, with slight olive tinge, very hard sandy clay, mottled with dark brown and yellowish-red. There are a few small concretions of manganese and iron, but not so many as suggested from published descriptions. Aubert says that similar soils exist in Morocco.

In the station while waiting for our car, the director speaks of "brownish-red sandy" soils with well-developed nazaz layers, which are not good for citrus. He says the layer is roughly parallel to the surface. After "degradation" the surface becomes thicker so that the nazaz may be very shallow on old hills, while that in the hollows has been partly covered with sand or local alluvium. When exposed to the sun, the nazaz becomes very hard.

He says that alfalfa gives a good structure to the loose sand of sand dunes in four years. He expects they shall then be able to have 2 or $2\frac{1}{2}$ years of vegetables, followed again by a legume forage. The experiments are being continued. About 75,000 acres of this undulating sand-dune area is occupied now by the Egyptians.

We are driven again over the rough road back to Jerusalem. We arrive at the hotel at 5:15, have dinner,

and get to the first (introductory) session of the Symposium on Desert Research at the YMCA.

We have the usual welcoming speeches by Mr. David Ben Gurion, the Prime Minister, the Mayor of Jerusalem, and the Rector of the University. A message is read from the President, who is ill. Besides these, there are greetings from the U. N., from UNESCO, from M. Monod, and from Mr. Ritchie Calder for the British A.A.S. Mr. Lowdermilk (now of FAO) gives a very general emotional talk. The program is quite dull. It is over about 10:00 p.m. and I walk back to my hotel. To bed at 11:30.

and get to the first (introductory) session of the

Symposium on Heart Research at the IMCA.

We have the usual welcoming speeches by Mr. Davis for this

the Prime Minister, the Mayor of Jerusalem, and the Rector

of the University. A message is read from the President,

who is ill. Besides these, there are greetings from the

U. S., from UNESCO, from M. Mead, and from Mr. Ephraïm Golder

for the British A.A.S. Mr. Lowdermilk (now of PAO) gives

a very general emotional talk. The program is quite dull.

It is over about 10:00 p.m. and I walk back to my hotel.

To bed at 11:30.

Preprint from

PROCEEDINGS, INTERNATIONAL SYMPOSIUM ON DESERT RESEARCH

Research Council of Israel in cooperation with United Nations Educational, Scientific and Cultural Organization.

Jerusalem

May 7-14

POTENTIALITIES AND PROBLEMS OF ARID SOILS

CHARLES E. KELLOGG

*Chief, Division of Soil Survey, United States Department of Agriculture,
Beltsville, Maryland, U.S.A.*

SUMMARY

Arid soils are defined and their broad distribution in the world is indicated. It is estimated that perhaps some 80 million additional hectares of arid soils could be irrigated economically *if* they were selected and managed according to the best skills available and if they were used under adequate administrative schemes devised for the purpose of developing all resources in combination.

The characteristics and use-capabilities of arid soils are contrasted to those of soils in humid regions. It is emphasized that the characteristics of arid soils have a very different significance under irrigation than they have in nature. Thus claypans, hardpans, and salt layers that do not interfere with natural drainage in desert conditions may cause soils to become swamped and salty if they are irrigated without providing structures for artificial drainage.

Thus predictions of the outcome of management practices involving irrigation on different kinds of arid soils are difficult. Because of the great costs involved, accurate predictions are necessary for success. Scientists may not yet be able to deal with every situation, but they can accurately appraise and adequately deal with most situations if teamwork is good among competent experts in hydrology, soil physics, soil chemistry, plant nutrition, and soil classification. But to omit one phase in the appraisal of arid soils is to invite the kind of failures—even disasters—that have been abundant in the history of irrigation agriculture. The value of teamwork in scientific inquiry and prediction is nowhere better demonstrated than in predicting the results of irrigating arid soils.

Since costs for irrigation are high at best, good incomes to cultivators depend upon doing an excellent job of water control and on the maintenance of high soil fertility, usually far above that of the natural soil, in order to take full advantage of all growth factors in optimum combination. It takes much more than water alone to have economic yields on arid soils. With responsive soil and good quality water, it is possible to raise crops efficiently in arid regions, even more

efficiently than on comparable soils in humid regions where dependence is placed on a variable rainfall.

A general procedure for exploring and developing areas of arid soils is outlined briefly. Attention is directed to some of the more urgent problems of soil research.

ARID SOILS DEFINED

Sharp lines rarely separate the major kinds of soils or climates from one another. Within a continent we may begin with the dry soils of the nearly rainless desert and, without passing over a sharp boundary, go to increasingly moist soils in humid regions until finally we reach the highly leached ones that are continuously moist. Along the way, aridity gradually declines, both absolutely and seasonally.

Considering those characteristics of the soils themselves that reflect their genesis and determine their behaviour, a more or less arbitrary upper limit of humidity is chosen for this discussion of arid soils. On the humid side of the boundary are soils that have some of the characteristics of arid soils because of low moisture during part of the time; thus some principles governing the functioning of arid soils apply partly at least to these other soils. On the arid side of the boundary some soils are kept moist through irrigation; and the principles that govern the functioning of humid soils apply partly to them.

For practical reasons in this discussion, arid soils are defined as those too low in moisture for the growth of crop plants without irrigation. Roughly, these are the soils of desert and semi-desert regions.

In terms of great soil groups, arid soils thus defined include Desert, Sierozem, Brown, and Reddish-Brown soils¹, and their azonal and intrazonal associates, but not the Chestnut, Chernozem, and Reddish Chestnut (southern Chernozem) soils of the steppe, even though these are too dry for crops of the time. Even this definition does not separate the great soil groups cleanly; a small part of the Brown and Reddish-Brown soils can be used economically for cereals grown alternately with tilled fallow. The definition does not separate irrigated soils from nonirrigated ones. Irrigation extends well into the humid regions to moisten soils that are dry for only short periods. The definition is meant to include, however, soils that *must* be irrigated for most practical agriculture beyond extensive grazing.

GEOGRAPHY OF ARID SOILS

The distribution of desertic or arid soils, as broadly defined in this paper, is shown on the schematic map of the world in figure 1. The areas thus shown amount to a bit under $3\frac{1}{2}$ billion hectares, or nearly 30 per cent of the world's land area.

Approximately 110 million hectares of soil is irrigated. We may estimate that a little less than one half of this, or about 41 million hectares, is arid soil.

Based upon a review of many published estimates for individual areas, including estimates of the United States Bureau of Reclamation, we may roughly estimate that 80 million additional hectares of arid soil could be irrigated, *provided* institutional arrangements were developed that would allow full use of modern techniques and permit taking full advantage of the opportunities for combined use of resources.

Besides arid soil, as here defined, irrigation would benefit many more hectares – perhaps as much as 400 million – of soil that respond to supplemental water in dry seasons.

This estimate of potentialities should not be taken as more than a rough guide to the order of magnitude of the potential area. So much depends upon both general and local economic and institutional conditions. The creation of favourable conditions in many places will be difficult and slow at best. After detailed soil and water surveys are made, this figure may be revised.

CHARACTERISTICS OF ARID SOILS

Perhaps the significant characteristics of arid soils can be shown most easily by comparing them to other soils, especially to those of western Europe and the eastern part of the United States. Let us begin by looking at the broad principles of soil geographics in bold outline.

Soils are natural bodies with characteristics resulting from the integrated effects of living matter and climate, acting upon parent rock material, as conditioned by relief, over periods of time^{6,7,16}. Similar combinations of these five factors produce similar kinds of soil. Thus soils are distributed over the earth in an orderly, discoverable pattern. This pattern is related to the distribution of the interacting genetic factors, although not directly to any one by itself. Thus, in their geography, soils contrast sharply to rocks, which are distributed more or less promiscuously on the earth in relation to the existing environment.

Local differences in soils, say between one field and the next, are usually related in parent rock, relief, or time. The broad fundamental differences among soils of regions are related primarily to differences in living matter and climate.

As a standard for reference in soil geography we may begin with the so-called “normal” soils¹⁶. These are soils having characteristics in equilibrium or nearly in equilibrium with their environments, developed under good but not excessive drainage from parent material of mixed mineralogical, physical, and chemical composition, and expressing the full effects of the forces of climate and living matter.

The various groups of normal soils are called *zonal* because they occur in general harmony with the climatic and biologic zones. Their boundaries are not precisely coincident with those of climatic types and vegetation. They do not coincide exactly, especially in the tension belts between the zones, because the three local factors of soil formation modify the effects of climate and living matter, and because parent materials of different ages may exist in mixed patterns.

Some soils are too young to have developed characteristics. These include the Alluvial soils being formed in deltas and along streams and the thin soils on rapidly degrading slopes that have not been reduced to their angle of repose so that weathered rock material can accumulate. These soils are called *azonal*; they may occur within any soil zone.

Still other soils have well-developed characteristics, but in their formation some local factor of relief, drainage, or parent material has overwhelmed or at least significantly modified the normal processes to give the soils unlike characteristics as compared to those of associated normal soils reflecting mainly the effect of living matter and climate. The dark-coloured swampy soils of humid regions and salty soils of arid regions are examples. These are called *intrazonal*; they may be associated with two or more kinds of zonal soils^{1,6}.

Returning now to the zonal soils, or groups of normal soils, we may recognize five principal specimens, with all manner of transitions among them. These are, (1) the tundra soils of very cold humid regions, (2) the latosolic soils of very warm humid regions, (3) the desert (arid) soils of very dry regions, (4) the chernozemic soils of temperate steppes, and (5) the podzolic soils of temperate or cool-temperate woodlands. The broad geographic relationships among these five zones are set forth schematically in figure 2.

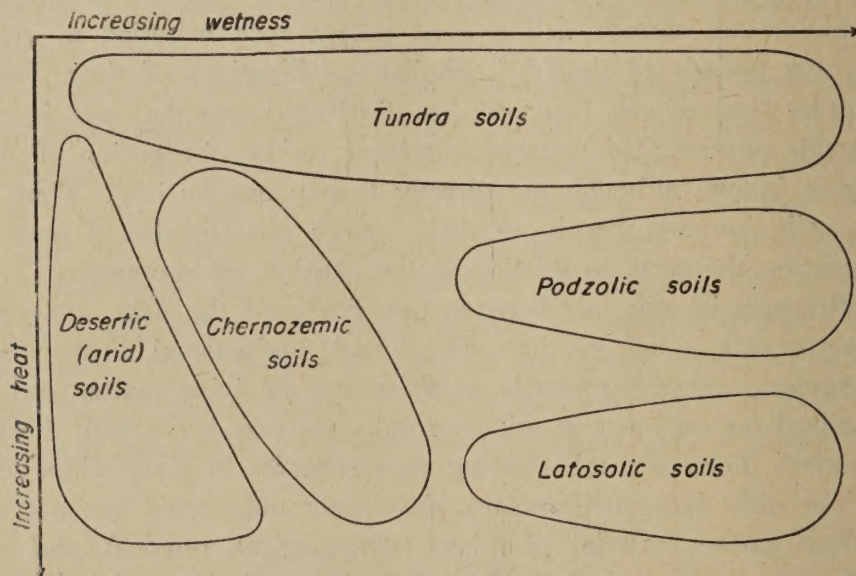


Figure 2.

A schematic diagram showing the broad geographic relationships among the five major groups of zonal soils.

Taking the arid soils as a whole we may now compare them to those of other regions.

Proportion of Normal Soils

Because of low moisture, scanty vegetation, and occasional catastrophic showers, normal erosion is very active under natural conditions in the arid zone. As a general rule, the lower the annual rainfall the greater the proportion of the surface that is actively eroding or receiving erosion products. Since surfaces are so unstable in relation to the rate of soil formation, arid regions have a low proportion of normal soils – thus a low proportion of zonal soils and a higher proportion of intrazonal and especially of young azonal soils. The largest part of the landscape consists of rocky slopes washed free of fines, wind-swept rubble-covered plains and broad stream channels and alluvial fans, moving sand dunes, broad alluvial flats, salt-rich basins, and wind-swept rolling plains of *croûte calcaire* or hard rock. Rushing torrents fill the stream channels for short periods between long intervals of drought. Thus, in the uplands of arid regions, angles are sharp in contrast to the rounded hills of well-watered soils protected by luxuriant vegetation.

Normal soils in arid regions are confined to the relatively old, nearly level plains and mesas. Actually, the larger part of the best soils for agriculture are on the relatively young alluvial fans, flood plains, and deltas where the fines have accumulated. Besides, these Alluvial soils are lowest in elevation in relation to potential supplies of water that may be impounded in streams from the uplands. Yet, because of their position to receive seepage water from the higher elevations, these lower-lying soils are subject to harmful salt accumulations, especially if drainage is in any way restricted. The older normal soils are commonly high on the nearly level mesas above the streams. Yet, these are sometimes useful for irrigation where water can be impounded in still higher uplands or mountains. Many normal soils that can be reached with water are among the most productive of all under irrigation.

Soil-forming processes

Both physical disintegration and chemical breakdown reduce rocks to parent material for soils – “make little ones out of big ones” – and weather the mineral particles within the soils. In temperate, and especially in warm, humid regions the chemical processes may be said to predominate; whereas in desert regions, the physical processes dominate because less water is available for hydration, solution, and leaching. Still chemical processes are important in arid soils. Particles of sand size in soils of humid regions are largely quartz because of the other minerals have dissolved or changed to clay; those in arid soils may consist of less resistant minerals, even of calcite or gypsum.

Changes in temperature are wide and important to weathering in arid regions. Because of the differential expansion and contraction of unlike minerals, rocks are gradually shattered, especially where daily variations reach high values well over 40° C and low values near or below 0° C.

The young soils of humid and arid regions are more nearly alike than the old

ones. As time goes on the more drastic chemical changes in the humid regions, especially warm humid regions, widen the differences in soil properties.

During comparable periods of time, soils of relatively low clay content develop in arid regions from kinds of rocks that give clayey soils in humid regions. Still some clay does form. An old desert soil, because of differential clay formation in place, may have a *B* horizon* quite rich in clay that contrasts clearly to a sandy or loamy surface soil and a relatively coarse-textured substratum. Since rains are only rarely sufficient to moisten the substratum, and since the surface soil dries out quickly after a shower, the *B* horizon has enough moisture for hydration and clay formation for a larger part of the time than either the *A* or the *C*. The *B* horizons of desert soils are generally thin as compared to those of other soils, say 8 to 20 centimeters. Only a very few are thicker¹⁴, because so much time in place is required to produce them under arid conditions. The clay minerals formed are the expanding lattice type, similar to those in chernozemic soils, and more active than the clays in latosolic soils.

The presence of this clay formed in the *B* horizon, plus leaching down through the structural cracks that occasionally takes place, produces old arid soil profiles that superficially resemble podzolized profiles of humid forested regions in which a significant part of the clay has been leached from the *A* into the *B* horizons.

Yet despite the relatively low rate of clay formation in arid regions, many arid soils are rich in clay. First of all, secondary rocks are important sources of soil material. These include fine-grained shales and mudstones that were formed by consolidation of old clays developed in earlier cycles of weathering. When exposed again to weathering and soil formation, such rocks give rise to clayey soils. Then too, the alluvial and lacustrine deposits in arid regions that have settled out of very slowly moving or quiet water are rich in clay. The coarse particles are dropped nearer the stream source from more rapidly moving water.

Very sandy soils are developed in arid regions from the breakdown of sandy sedimentary rocks, even of kinds of sandstones that give soils of moderate clay content in humid regions. Because of the dryness, scanty vegetation, and absence of clay to bind the particles together, the sands move with the wind and give rise to the shifting dunes commonly associated with desert landscapes. Actually a much smaller percentage of the deserts of the world are as sandy as commonly supposed. The vivid stories of desert sandstorms and the beautiful photographs

* That part of the soil profile developed by soil-building forces is called the *solum*. Its upper part, which is most directly exposed to climatic forces and in which biological processes are most intense, is called *A*. Its lower part, roughly equivalent to the old term "subsoil", is called *B*. The weathered material (parent material) beneath the *solum*, like that from which it has developed, is called *C*. Layers of hard rock or other nonconforming layers below *B* or *C* are called *D*. Soils developed under low rainfall commonly have accumulations of calcium carbonate, gypsum, or more soluble salts in the *solum* or beneath it, which are indicated as B_{ca} or C_{ca} , B_c or C_{cs} , or B_{sa} or C_{sa} , respectively. The many conventions for soil horizon descriptions and nomenclature are explained in the *Soil Survey Manual*¹⁶.

of dunes have combined to exaggerate their importance somewhat. Yet, the threat of starting catastrophic soil blowing and sandstorms compels us to caution against unnecessary disturbance of sandy arid soils unless their subsequent fixation through irrigated plantings or in other ways is reasonably certain.

It takes time for the soil-forming processes to produce a normal soil. Somehow the surface must first be stabilized, either by a surface accumulation of pebbles – desert pavement –, the establishment of plants, the formation of a resistant crust, or some combination of these. Beneath such protective crusts and pavements the arid soils are characteristically porous and cellular in the *A* horizon, partly as a result of wetting and drying and of gas formation during moist periods, and partly from the effects of roots and small animals. Many animals burrow into the relatively cool soils by day and go abroad to forage at night.

Although plants are widely spaced and biological activity is low in desert soils, the effects are by no means insignificant. Perhaps of first importance in arid soils is the rôle of vegetation in helping to stabilize the soil surface. It shields the soils from the full force of rain and wind. As in other soils, the roots help to keep the soil open and pervious to water. More of the water from a shower enters a soil covered with vegetation than one stabilized mainly by a crust.

The desert plants remove water and nutrients throughout the soil and bring them to the top. Thus are nutrients concentrated in the organic remains and their decomposition products while the water is transpired. The amount and kind of materials taken up by individual species vary widely. Some desert plants take up little salt; the leaves of others have as high as 10 per cent sodium chloride on a green-weight basis. The long growing of such a shrub has a great influence on the chemistry of the soil. Thus only a few feet apart, the soil under one shrub may be rich in sodium salt and extremely alkaline and that under another may be relatively low in sodium and only mildly alkaline.

At one time it was thought that plants adapted themselves to different kinds of soil wholly through selection and competition. Although such selection is very important, we now know that the different kinds of plants themselves strongly modify the soil on which they grow³.

Even though soil leaching is low in arid regions, the permeable well-drained soils are leached, first of the more soluble salts, such as sodium chloride and sodium sulphate, and increasingly of gypsum and calcium carbonate. These may be leached entirely out of the solum and accumulated in layers beneath it; but if abundant amounts are present to begin with, the leaching may only reduce the amounts in the surface horizons – not eliminate them – and give rise to accumulations in the *B* as well as in the *C*.

The accumulation of calcium carbonate by leaching from above is commonly combined with accumulation from a lime-rich ground water beneath the soil to give thick masses of calcium carbonate below the solum. Thus, these accumulations of calcium carbonate in arid soils, loosely referred to as *caliche*, vary widely

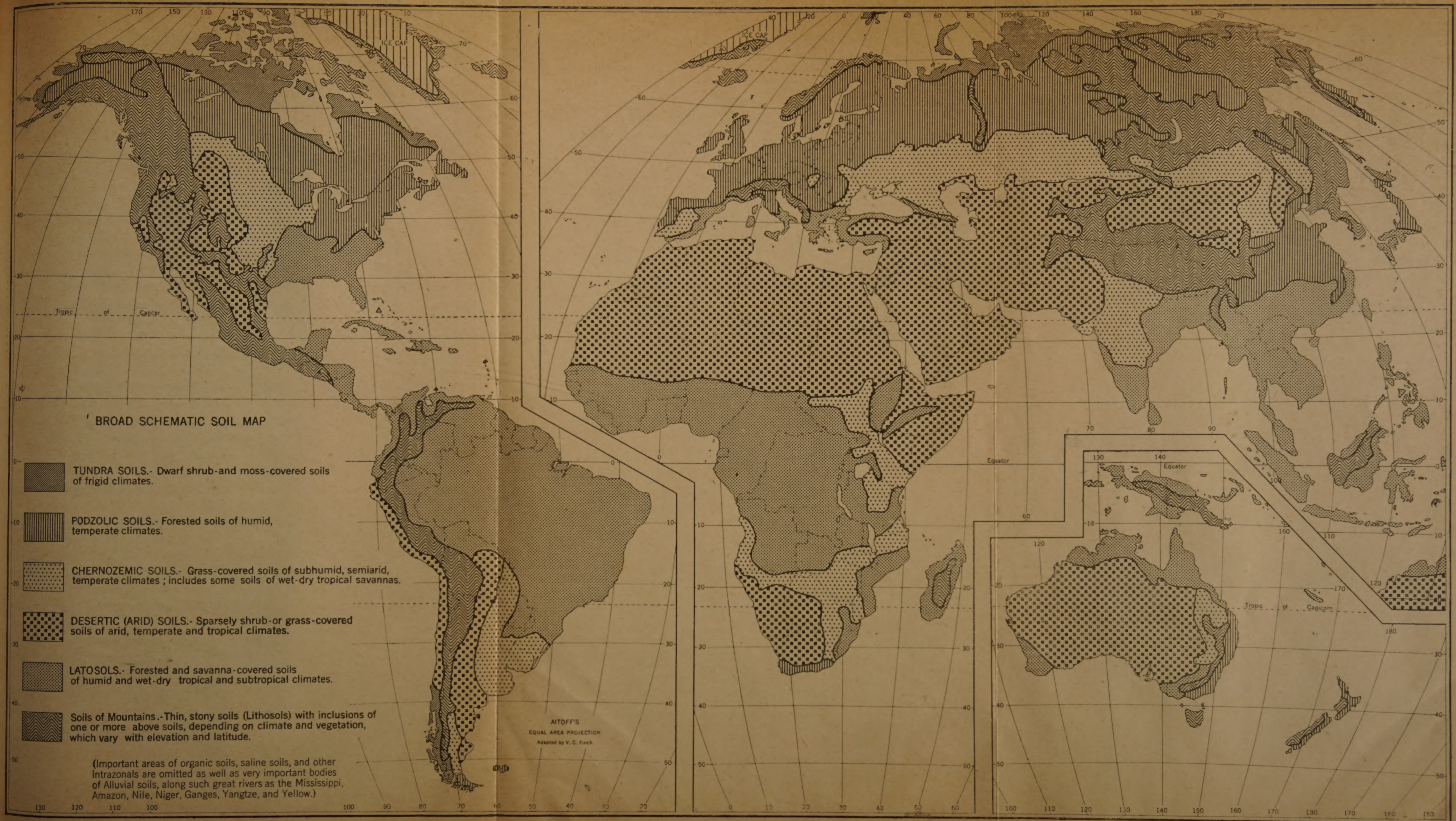
in both thickness and composition. Commonly they harden to *croûte calcaire* or hardened caliche with exposure or where the solum is very thin, especially in warm regions. On the fringes of the desert, and even in deserts that are drier now than formerly, one may find layers of *croûte calcaire* many feet in thickness. Any process that stimulates soil erosion or soil blowing, such as recent uplift or weakening of the vegetation by reduced rainfall, overgrazing, or excess tillage, removes the solum and leaves the *croûte calcaire* as a massive surface crust. Wind-swept *croûte calcaire* now accounts for large areas in warm deserts and semi-deserts. Some of these areas owe their origin to natural processes; others have resulted from bad soil use that could have been controlled. Science still lacks firm principles for assessing the basic causes accounting for these crusts in the majority of individual areas where they occur.

Products from the leaching of arid soils collect wherever the water evaporates. As already explained, much of the calcium carbonate and gypsum accumulates in layers just beneath the leached soil, but the more soluble salts go farther. In humid regions water collects in the low places and gives rise to swamps. Peat forms. In arid regions salty water collects in such low places, giving rise to intermittent brackish ponds. Salts accumulate in soils on seepy slopes where the water evaporates. Salts may rise into the solum, or even to the surface, from a salt-charged water table, not only in playas and basins but also in alluvial flats or from new water tables produced by irrigation, even in the uplands. The combinations of kinds of salts, amounts, and their relative vertical distribution in the soil profile are almost infinite. Rarely are salty soils uniform over broad areas; commonly they are very spotted and irregular.

The salts affect the characteristics of the soil and directly influence the plants. Most crop plants are injured by concentrations of salt greater than about 0.15 per cent and are prohibited from growth if the salt concentration exceeds 0.65 per cent. But these effects are modified by the kind of salt, the physical characteristics of the soil, the amount of water, and the alkalinity of the soil*.

If the salts that come into the soil are rich in sodium, the sodium ions replace others in the exchange complex of the clay to form what is sometimes called "sodium-clay". In the presence of excess salts such clays are flocculated; but with reduction of the salt content through improved drainage (either natural or artificial) and leaching, the sodium-clay becomes strongly alkaline and easily dispersed. When wet, the soil "runs together" into sticky masses that harden upon drying. Thus saline soils may pass to alkali soils—soils having a pH value above 8.5, 15 per cent or more exchangeable sodium, or both. Such alkali soils are unsuitable for crop plants unless reclaimed through improved drainage, replacement of the sodium with calcium, and other practices to reduce the pH and improve the

* In present-day soil examinations results are commonly expressed as conductivity of solution extracts^{12,16}.



structure. Strongly alkaline soils, especially those rich in clay, are likely to be very sticky and impermeable to water. Many of them must be avoided. The practicality of their improvement depends upon the cost for treatments, drainage, and irrigation, the quality of the irrigation water, and the value of the crops to be grown*.

Soil characteristics

Soils have two kinds of properties that interest us in appraising their behaviour and potentialities: (1) the observable characteristics that may be seen directly in the field or learned through examination in the laboratory of samples representing the significant horizons; and (2) qualities that may be interpreted from the observable characteristics and the results of field trials including the experience of cultivators, on areas of defined kinds of soils.

Let us try to summarize broadly how the characteristics of arid soils compare with those of other soils, realizing that these are generalizations applying unequally to many thousands of different local kinds of soil. Differences in kind and degree of soil horizon differentiation due to soil-forming processes, beyond the differences in parent material, are generally of greater agricultural significance in humid than in arid regions.

Texture profiles. Old arid soils normally have at least some concentration of clay in their *B* horizons—in many a great deal, but usually less than in old podzolic soils. Clay contents are generally lower than in other soils, especially than in the latosolic soils of the humid Tropics. Since a large proportion of the soils of arid regions are relatively youthful and are developed on water-laid terraces and fans, they have almost every conceivable combination of texture profiles—all sand, all clay, sand over clay, clay over sand, and the like. Commonly, the subsratum is sandy or gravelly and the solum loamy or silty. The texture profiles of many desert soils have been greatly altered by irrigating with muddy water for several years. Many started out as rather sandy soils, for example, and now have deep silty coverings of fine materials left from the muddy water.

Structure profiles. Mature Desert soils commonly have thin, vesicular crusts at the very surface that are immediately underlain by granular soil. Except in sandy types the *B* horizons are blocky or prismatic. The layers of lime accumulation are commonly massive, but these vary in consistence from soft to hard. With increasing rainfall and grass cover, the surface crust disappears, the prismatic structure of the *B* becomes more pronounced, and the layer of lime accumulation becomes generally deeper and thicker. The *B* horizons of clayey soils strongly influenced by sodium have an especially hard prismatic structure. Except for these soils rich in sodium-clay, arid soils are less likely to lose their structure

* It is not possible to go deeply into this complicated subject. The reader may consult some of the citations for a start 2,3,4,11,12,*3.15,17,18.

with tillage and become massive than the podzolic soils. On the other hand, even with irrigation, it is difficult to maintain granular or cloddy structure in sandy arid soils that are coarser in texture than a loamy fine sand*.

Organic matter. Arid soils are normally low in organic matter because of their scanty vegetation. From the driest Desert soils to the thick Chernozem of the subhumid steppe, the content of organic matter in the soil rises from well below one per cent to a high of nearly 10 per cent. Thus arid soils, when given irrigation, are notoriously deficient in the nitrogen needed for good crop yields. Although a general relationship exists between the darkness of soil color and the content of organic matter, there are many exceptions, especially in warm areas. Some nearly black soils in tropical and subtropical lowlands may have less than two per cent organic matter.

Reaction. Arid soils are rarely less than neutral; that is below pH 7.0, and are commonly alkaline. Where the alkalinity is due mainly to calcium-clays and calcium carbonate, the soils are said to be *calcareous* and their pH values are generally below 8.4. Soil pH values of 8.5 and higher suggest the presence of sodium-carbonate. Commonly the sodium carbonate originates within the soil: sodium hydroxide forms by hydrolysis from the sodium-clay and reacts with carbon dioxide from the air to form sodium carbonate. Besides the adverse direct effect of high alkalinity on plant growth, these high values of soil pH suggest difficult problems of soil tilth and permeability under irrigation.

Thus liming, which is generally essential for good crops on podzolic soils, is not required on arid soils. In fact it would injure most of them. The high contents of calcium and the alkalinity of arid soils depress the solubility of several plant nutrients, including phosphorus and iron.

Salinity. Arid soils generally have a higher content of soluble salts than other soils. We have already seen that saline soils too salty for crop plants, and alkali soils too alkaline for crop plants, are common features in the arid region.

Plant nutrients. Under the natural environment, deficiencies of plant nutrients rarely limit the growth of plants in arid soils. Water is the dominant limiting factor. But with irrigation, deficiencies of plant nutrients can become critically limiting. Of first importance is nitrogen deficiency, associated with the low content of organic matter. Amounts of phosphorus in arid soils vary widely; they are commonly too low for good yields and occasionally are very low. Potassium is usually plentiful, but with long cultivation it becomes limiting on some irrigated soils, especially the sandy types. Calcium and magnesium are nearly always abundant. In relation to these elements and to the alkalinity, amounts of available iron and zinc are often too low^{5,13,19}. Loss of green colour (chlorosis) of the leaves of crops is a common problem related to unbalance among the nutrients in arid

* At least 50 percent fine sand and very fine sand; the percent of silt plus $1\frac{1}{2}$ times the percent of clay is above 15; and the percent of silt plus twice the percent of clay does not exceed 30¹⁶.

soils. In many instances the causes of chlorosis are obscure, and basic research in this field is needed*.

Soil qualities

In the appraisal of the optimum use and management of any specific kind of arid soil, interpretations of combinations of the characteristics are required.

Soil drainage. "Drainage" is a broad term used widely in different senses: (1) as a method of reclamation to make well-drained soils out of poorly drained soils, (2) as a dynamic process of water movement from the soil to underground spaces, and (3) as a condition of the soil itself.

As a condition of the soil, drainage refers to the frequency and duration of periods when the soil is free of saturation or partial saturation with water. Thus the drainage class of a soil depends upon the additions of water through precipitation (or irrigation) in relation to losses by percolation ("active drainage"), evaporation, and transpiration. Soil drainage is not a soil characteristic to be observed. We do observe water standing on the surface, depth to the water table at various periods, salt layers, mottled soil horizons, rates of out-flow in test holes, and other evidences that we *interpret* in order to assign a drainage class to a soil¹⁸.

Thus nearly all arid soils are well-drained under the natural environment, even including those having impermeable layers in or beneath the solum through which little or no water percolates. Exceptions are the low places where excess water from other soil accumulates all or part of the time. These low places have saline or alkali soils.

Many arid soils that are well drained under natural conditions become poorly drained under irrigation. No quality of arid soils is more important to irrigation farming. The successful soil classifier must be able to predict what the drainage will be under different irrigation practices and be sure that the soil characteristics are such that no waterlogging will develop or that drainage structures can be economically installed to prevent it. Likely more irrigation projects have failed from faulty predictions on drainage than from any other single cause. Either the soils become waterlogged and salty or else water goes through the soils so rapidly that uneconomic amounts are required to maintain adequate moisture in the rooting zone. Rarely can successful irrigation be expected unless at least part of the water can penetrate freely into the substratum and out through natural cavities or installed drains.

But we cannot be absolute on this point. It is possible, as shown in the Gezira scheme near Khartoun of the Anglo-Egyptian Sudan, to adjust the additions of water through irrigation so that removal by evaporation and transpiration balance the additions without waterlogging, even though little or no water percolates through a dense substratum². In such rare borderline situations, the salt content must also be kept in balance, that is, plants must remove the salts added in the

* For an excellent discussion of plant deficiency symptoms with beautiful illustrations, see Professor T. Wallace's recent book²⁰.

irrigation water. Success under such conditions obviously depends upon having high quality, nearly salt-free water for irrigation. Such high quality water is not commonly available.

Salinity and alkalinity. Besides the existing salinity and alkalinity of a soil, the soil classifier must be able to predict the conditions that may develop under irrigation management. These are closely related to drainage and to the abundance and quality of the irrigation water. Under proper conditions both salinity and alkalinity may be ameliorated^{17,18}, but, without proper precautions, they may develop in soils initially low in salts or in alkalinity. Theoretically, nearly any kind of soil *can* be made productive; but in many situations of poor drainage, bad soil structure, and complexity of soil pattern, it is wholly uneconomic to make them so. Such conditions need to be predicted and avoided before any works are attempted.

The concept of *salt balance* is a useful one to apply in any given situation. This simply means taking account of all salt removed through drainage (and crop harvests, if significant) in relation to additions in the irrigation water or through seepage. The system must come into a balance below the critical point where salt concentration injures plants without the use of excessive amounts of water or of uneconomic structures and practices. Since irrigation water is used over and over again in the sense that the discharge from one area goes into a stream tapped for the irrigation of lower-lying areas, one needs to consider the salt balance of the whole complex drainage system.

In soils nearly impermeable to water the salt balance may possibly be so delicate that by removing all the cotton plant, let us say, not simply the cotton fiber alone, the salt removed can be made to balance the additions; while otherwise salts would gradually accumulate. On a *very* few borderline soils it may be practicable to grow a few crops of salt-loving plants as a means of lowering the salt content just enough to get below the level of toxicity. Such instances are rare.

Soil scientists are continually improving their ability to make accurate predictions about the use and reclamation of saline and alkali soils. Importantly involved are the physical properties of the soil in relation to water retention and movement, soil chemistry in relation to the physical properties of the soil and to plant nutrition, and also the quality and amounts of available water. No one set of results gives reliable predictions, however, and many anomalies are still unexplained. But real progress can be made by combining the evidence from hydrology, soil physics, soil chemistry, plant nutrition, and soil morphology, in relation to carefully defined kinds of soil. One could scarcely find a better example of the great benefits to be derived from the interactions among skills where teams of scientists work together. Probably not all, but certainly a large part of the specific problems of saline and alkali soils could be solved now by such teams of competent scientists, but the omission of one phase—hydrology, soil physics, soil chemistry, plant nutrition, or soil classification—is an invitation to failure.

Tilth (or physical condition of the soil.) A productive soil is permeable to water and roots. Ideally the soil particles are grouped into granules or small blocks or clods that remain firm but friable. They do not run together in masses or separate into single grains. The soil should not become waterlogged and exclude the air essential to plant roots; yet it must hold water for plants between irrigations of moderate frequency.

The presence or development of sodium-clay is a hazard to the tilth of arid soils. Although such soils crack during very dry periods, the clays swell and become massive with moistening. The amount of swelling varies among kinds of soil but is a great hazard in the use of alkali soils under irrigation. Through drainage, chemical treatment, and the use of proper crop rotations such conditions can be ameliorated or prevented. Here again, however, costs are excessive with many local kinds of soil and these must be avoided.*

At the other extreme are the very sandy soils, so low in clay that the sand tends to separate as single grains rather than aggregating into firm granules. To maintain tilth in these soils, the humus content must be kept fairly high through the use of manure or compost, the growing of green-manuring crops, the maintenance of thick-growing crops in the rotation, or some combination of these practices.

Very sandy soils can be used if heavily irrigated, but this means that water must be cheap and that nutrient losses from leaching will be large. Such heavy irrigation increases the hazard of salinity and waterlogging in soils on lower-lying benches. Thus, advantage should be taken of any economic methods for improving the tilth of such sandy soils. Soil-building crops, such as guar (*Cyamopsis tetragonaloba*) and sesbania (*Sesbania exaltata*) for example, make a large vegetative growth during short periods and can be used in warm regions during the summer for building up the humus supply and improving the tilth of sandy soils.

The variations in physical conditions need to be recognized in the selection of management practices. Slowly permeable soils may be irrigated in long runs (little ditches), say of 400 to 500 meters, and with low heads, giving the water plenty of time to soak into the soil. On very sandy soils, where permeability is high, the runs should be much shorter, say 100 meters or less, and the heads larger so that water gets to the lower end of the runs¹³.

Fertility. Generally, the fertility of arid soils is lower than commonly supposed. Although less leached than podzolic and latosolic soils, arid soils are low

* At the annual meeting of the American Association for the Advancement of Science in Philadelphia December 29, 1951, a new synthetic soil conditioner was announced that may have far-reaching value for improving the structure of clayey soils, including those rich in sodium-clay (alkali soils). Although much research and testing remains to be done, preliminary results are very promising with amounts as low as 0.1 per cent or less in the treated soil. Apparently the only effect is to produce stable soil aggregates with no direct effects on the chemical and biological properties of the soil. But the resulting aggregation has great effects on water intake, percolation, root extension, and the maintenance of a proper balance of moisture and air in the soil. The set of papers given at this meeting is to be published soon in *Soil Science*. The Monsanto Chemical Company expects to have the material available under the trade name "Krilium".

in nitrogen and commonly, but erratically, low in available phosphorus. It takes a great deal more than water to make "the desert blossom like a rose". A few arid soils, such as some of those along the Nile and other streams, have been kept reasonably fertile by additions of clay and silt carried to them in the irrigation water. Usually, however, the water does not add significantly to the fertility, and may actually reduce it by bringing in harmful quantities of salt or even special toxic salts such as borax.

Although the original amounts of available plant nutrients may be sufficient to produce good crops for a few years after irrigation begins, these supplies are usually soon exhausted and must be replenished by chemical fertilizers to maintain the proper amounts of nutrients and a proper balance among them.

Most important of all, however, is the fact that successful irrigation depends upon the maintenance of high yields in order to compensate for the extra expense of supplying water. High costs for the water system can only be met practically by eliminating low soil fertility as a limiting factor in order to get full benefit from the water and the other growing conditions. Rarely is it possible for cultivators to have a high labour income from irrigation farming unless soil fertility is kept high—considerably higher than that of the untreated natural soils.

Erosion hazard. The hazard that any particular kind of soil may erode under use depends upon the cover and the sharpness of the showers in relation to soil permeability and soil slope. If the soil is extremely permeable and can take in water rapidly, erosion hazard is low even on strong slopes. Very slowly permeable soils are erodible, even on gentle slopes, since most of the water from sudden showers runs off the surface.

We have already seen that natural erosion is strong in arid regions because of the occasional catastrophic showers and the scanty surface cover. It is easy to initiate active accelerated erosion on sloping soils of low permeability by overgrazing that weakens the plant cover. By no means all active erosion has been accelerated through use, as some emotional writers imply. Near the margins of the desert, for example, increases in aridity for a few years weaken the vegetation and initiate erosion, quite regardless of grazing practices. If moisture increases the vegetation increases, and then herdsmen tend to overstock the land, such overstocking during the following dry or even normal periods leads to overgrazing and accelerated erosion.

Even nearly level soils are not entirely free from the hazard of erosion. Uncontrolled torrents from the uplands may cut new channels through nearly level terraces to the rivers. Such torrents must be controlled through dams or combinations of dams, spillways, and dikes.

Sloping soils can be irrigated from curving canals built at a slight angle to the contour, provided that no salt damage takes place from seepage, and that down-slope laterals or feeders are short. Since the carrying capacity of water increases with the sixth power of its velocity, down-slope irrigation ditches must

be short; otherwise the water flows so rapidly that only a small part can soak into the soil and much soil is carried along with the water.

Small inequalities in soil relief may be reduced by leveling to avoid short steep slopes, *provided* this does not expose very limy, salty, clayey, or gravelly layers beneath. Where leveling is impracticable, sprinkler irrigation is often economical, especially with the newest equipment. With proper adjustment, the water can be added slowly and controlled to avoid both excess runoff and excess percolation.

Soil blowing. Dry, finely granular or single-grained soil without a plant cover blows away whenever it is exposed to strong winds. The process continues until moist soil or a hardpan is reached or until a pavement of clods and pebbles is formed on the new surface. Arid soils are, of course, especially subject to this hazard, both in nature and under cultivation. Soil blowing can be controlled through the maintenance of vegetation, a cloddy surface soil, or closely spaced windbreaks, or through some combination of these practices.

Hazard of grading. Leveling soil by grading out the higher spots and filling in the low places is commonly a practical way to prepare it for irrigation with little ditches or within borders. Where soils are relatively uniform for considerable depths no special problems arise. Yet soils having sola only 30 to 70 centimeters deep, let us say, over layers of calcium carbonate, coarse gravel, or sodium-clay are greatly injured by such treatments. Without grading, such soils may produce quite well with sprinkler irrigation, but after grading it may be difficult or even impossible to develop the necessary surface rooting zone of fertile granular soil in the spots where the solum was removed.

CHANGES IN ARID SOILS WITH IRRIGATION

By irrigation we bring the moisture additions of a humid climate to the desert. This great change in the environment gives combinations of soil characteristics a drastically different relevance to all soil qualities than they have naturally. This fact makes prior examination of arid soils and predictions of their quality under irrigation difficult. The failure to make such examinations and predictions accurately, and in detail, either from simple neglect to do so or because of incompetent soil classifiers, is a major factor in the failures of irrigation projects. And those failures have been abundant, perhaps far more so than most of us realize, because we see few of the remains. The desert soon reclaims as wild land the abandoned soil.

Irrigation of arid soils does not change the whole environment. Humidity, except locally, remains low, and light intensity high. Crops introduced on irrigated arid soils often escape the diseases and insects of their native humid environments. Yet they may acquire new ones. Then too, if the predatory insect does reach crops on the arid soil, its natural enemies may stay behind and thus allow even greater damage.

Most vital are the effects of irrigation on the drainage and salt balance. Hard-pans, and salt layers, of little or no influence on the behaviour of the soil in its natural environment, become extremely important with the greatly increased moistening and water movement under irrigation.

The rooting zone of plants should be free of excess water and salts. Ideally, the water tables should be two meters below the surface, and three meters is better; but fairly successful farming is carried on with the water table at one meter or even less. In many instances, the water table fluctuates with the seasons, in places as widely as from one-half meter to 10 meters, for example.

If the irrigation water itself is fairly salty, more water is required to percolate through the soil to get rid of the excess salts than if irrigation is with pure water. For example, if the irrigation water contains 100 parts per million of salt – and this is water of good quality – the use of a meter of it in one year means the addition of about 1,000 kilograms of salt per hectare. But much irrigation water runs as high as 500 parts per million of salt. This means that a meter application has nearly 5,000 kilograms of salt. Thus, of the water added, some must drain through the soil to carry away the salt. With these relatively high amounts, probably around one-fourth of the water added should pass through the soil for this purpose alone. Only good drainage can take care of it – either good natural drainage or artificial drainage.

Then too, abundant salt causes a part of the soil moisture to be physiologically unavailable to plants, thus raising the total amount of irrigation water needed.

Many arid soils with low clay contents – loamy fine sands, for example – can be made highly productive under irrigation, whereas soils in the humid region that are so sandy ordinarily do not hold enough water for plants from one rain to the next. This fact is an example of the general principle that no valid correlation exists between any one soil characteristic (single factor) and soil productivity. Always we are dealing with a combination of soil characteristics reacting with a combination of management practices. The effect of any one characteristic or of any one practice depends upon the others in the combinations and the interactions among them. More errors are made in soil science from failure to observe this principle than from any other cause^{7,16}.

This principle applies to management practices as well as to soil characteristics. For example, close spacing of plants gives the highest yields with ideal soil moisture and soil fertility, whereas a wider spacing gives better yields if moisture and fertility are limiting. Thus, because of interactions among the practices, the advantage of one set over another set is often severalfold greater than the simple addition of the single increases from improvement of the individual practices, one by one, within a fixed combination. That is, in field trials to compare improved management over current practice, a change to ideal moisture may give a 10 per cent increase in yield, and a change to ideally balanced plant nutrients a 10 per cent increase. But by doing both of these and spacing the plants more

closely, the result may be a 50 per cent or 100 per cent increase. Many of the spectacular recent advances in soil management have come from this recognition of the need for considering combinations of practices that maximize the results of the interactions. It is the combination that gives the effect and we cannot precisely assign a percentage to any one practice.

Besides the changes irrigation makes in drainage and salt content of arid soils, are changes in surface texture and tilth caused by the addition of muddy water. Irrigation water from the Colorado River in the United States, for example, was very muddy prior to the building of a big dam on the main stream. Before the dam was built this water went onto a varied pattern of soils in the southern part of California. The mud deposited from the water gave all these soils a fairly uniform deep silty surface soil, but their substrata are widely different.

SPECIAL ADVANTAGES OF ARID SOILS

Despite the many problems already emphasized, crop yields can be very high under irrigation and can be kept high. In fact, the planning of irrigation projects in arid regions should aim at high yields through rigid selection of only the responsive soils and the use of practices to maintain excellent tilth, ideal moisture, and high fertility in the rooting zone.

Since water control in arid regions is costly at best, it is most practical, as a rule, to do an excellent job and to avoid soils where this is not possible. Then with ideal moisture and abundant sunshine, highest returns come with a high level of fertility and with maximum yields. Because of opportunities to control water and to establish ideal sets of growing conditions, crops *can* be grown efficiently with good management on responsive arid soils—perhaps even more efficiently than on productive soils in humid regions where dependence must be placed on variable rainfall.

Yet partial failures in drainage or salt control can reduce yields so much that the resulting income from the total effort is very low.

Then too, the great advances in soil science and engineering in recent years make it possible to do a much better job of predicting soil behaviour under irrigation and of controlling the water, salt, and fertility within the soil. It would be impossible to overemphasize the fact, however, that these new advantages are realized only if all the relevant skills are employed in combination.

SOCIAL MANAGEMENT OF ARID SOILS

Farming is carried on in individual management units, or firms, either large or small. Management decisions that affect sustained production are made within these units. This perhaps the most important single fact conditioning programs designed to develop and to improve agriculture^{8,9}.

These decisions made within farm boundaries are greatly influenced by social and economic conditions and by the institutions that serve farmers. That is, if there are no fertilizers – no factories to make them, no transport to carry them, and no funds to buy them – farmers cannot decide to use them. If there are no schools, boys and girls cannot attend them; and they shall have no better basis for making decisions than their parents.*

In arid regions these off-farm decisions are especially vital. Except for extensive grazing and local irrigation from springs, wells, or small impoundments, the very presence of farming depends upon social decisions outside the individual farm.

The concept of the relatively independent farm family developed more easily on the podzolic soils of western Europe and of the eastern part of the United States than on irrigated arid soils. Most irrigation requires a relatively high degree of social control from the very start. The construction and maintenance of huge dams and canal systems require cooperation. For most practical results, irrigation, drainage, torrent and flood control, power development, and perhaps navigation must be provided for within one general scheme. Highly competent engineering and scientific services are necessary to appraise soil and water situations, to build the works, and to maintain the system. A central water master whose decisions are respected is necessary to control the water in accordance with supplies and with the competing claims for it within a prescribed framework of rights and priorities.

Organizations to carry on these functions may be private associations and co-operatives, existing local governmental units or new "irrigation districts" organized for the purpose, regional administrations, or functional departments of the central government.

Certainly the trend is toward a higher proportion of large schemes for which only the national government can be expected to have the financial resources. This inevitably means a large measure of national control to insure the soundness of investment. Yet success depends also on a large measure of local responsibility and participation in the planning and management if the off-farm decisions are to be reasonably consistent with the requirements for developing the most nearly optimum combination of practices within the individual farm units. Although irrigation farming is not importantly involved, the Tennessee Valley Authority in the United States is a successful and economical device for combining national powers and local responsibility on a regional basis for combined resource use.

It is not possible to go beyond this broad picture of management requirements here, except to emphasize as strongly as possible that they must be met if soil selection and soil management are to be sound. Without assurance in advance

* Since UNESCO is co-sponsoring this program, I should like to emphasize that this need for basic education among rural people offers them by far their greatest challenge and opportunity to contribute toward an abundant and efficient agriculture.

of stable, competent, and honest administration of the system, none of the advantages to be had from modern science, and especially from the interactions of the various phases of land development, can be realized.

Then too, man has other goals besides production, or rather besides production and conservation together – sustained production. He hopes for freedom of opportunity, for access to resources under conditions that give the cultivator a fair return for his labour and genius, and for a chance to get ahead. Thus, the management scheme must be politically and economically fair, as well as stable and competently managed. The cultivators must, of course, abide by the decisions of the water master, or else chaos and failure are inevitable. But they need a voice in his selection and in modifying the rules under which he operates.

COMBINED RESOURCE USE

The use of soil depends also on the use of the other resources. Even the same kinds of soil produce quite differently in unlike economic environments. More and more, scientific agriculture at high levels of efficiency depends upon industry, transport, education, medical facilities – in fact on all the parts of a well-rounded economy⁸. In soil use we are not seeking any kind of mythical “natural balance” between man and his environment; rather we are seeking a *cultural* balance, using all the tools of natural science, social science, and engineering.

Only rarely can any single segment of modern economy succeed by itself in a community or region. To do so requires an enormous relative advantage. If an area is so wholly agricultural that all transport, schools, medical facilities, and other social services must come from farming alone, the soil must be excellent indeed. Many of the best agricultural areas of the world are located on soils that were of only mediocre quality to begin with. Generally, agriculture thrives best where industry and other resource uses supplement the general economy and share in the costs and benefits of the social services.

Thus the appraisal of arid soils for development under irrigation requires not only careful examination of the soil and water, but also appraisal of the other resources in relation to agricultural development and social services. Obvious examples include fuel and power for industry and mineral resources for mines and factories. Where roads and social facilities can serve two or more enterprises, efficiency is far greater than for a single one.

SUMMARY OF STEPS FOR ORDERLY DEVELOPMENT

Perhaps we may summarize best by outlining the steps for developing new areas of arid soils, assuming that the general research institutes and advisory services are now or will be developed to deal with the problems that are bound to arise. Although principles and guides can be had through the transfer of knowledge and skills to a new area from established areas outside having similar character-

istics, local research institutes are essential. We cannot depend wholly upon technical and advisory services based upon research in distant places. In attempting to reach a high level of crop production, which is generally the most economic level, local problems are bound to arise that can only be dealt with effectively within the area.*

1. Exploratory or reconnaissance soil surveys should be undertaken first, concurrently with water surveys and the examination of other resources, to see whether or not a proposed area has at least the minimum of potentialities for economically successful development. Methods for conducting such surveys are reasonably well standardized and many scientists have the skills to conduct them¹⁶.

2. Following the exploratory surveys, potentially irrigable areas may be selected and outlined with full consideration to the probable yields and management costs for the several kinds of soil, the amount and quality of water available, the amount and value of the crops that may be grown, the market prospects, the needs and proportionate costs of general social services, and the net development costs in relation to the prospective income.

3. After it has been determined that an area of arid soils is generally of good quality and that the development is economically feasible, a highly detailed soil survey should be made that includes the characterization of each kind of soil according to its physical and chemical properties in relation to plant response and management practices.

4. As part of the soil survey programme, or intimately cooperative with it, accurate estimates are needed of the responses of each individual kind of soil to the alternative combinations of management practices and their probable effects upon its long-time productivity. Research and experience outside of the area *on the same kinds of soil* can be used in making these estimates. Where such results are unavailable, special soil management research is required.

5. Predevelopment farms should be established as soon as possible, and before general settlement in a new area. Often enough water of comparable quality may be obtained by pumping or from local impoundments to begin such farms long prior to completion of the main dams and canals. On these farms it is possible to test the most likely crops and soil management practices, in combination, before the settlers arrive. After the project is completed, these and perhaps other farms can be continued under governmental management to serve as demonstration farms for the guidance of the new settlers.

6. Based upon the detailed soil survey, the estimates of production, and the location of canals and transport, the area can be subdivided into farms of practical size and the land appropriately classified¹⁶. The land classification in this sense

* Many recent statements about technical assistance programs for new and undeveloped areas omit sufficient emphasis on the need for research institutes. Some of the statements promise more for an advisory program by itself than can possibly be delivered. An advisory service cannot go very far without supporting research *within the same region*.

is a classification of the individual areas according to all the physical and economic characteristics that are relevant to their use by cultivators¹⁰.

SUMMARY OF RESEARCH NEEDS

As already explained, scientific work with arid soils can be done best by teams of experts. Especially with the development of arid soils through irrigation, the environment is drastically changed to produce new farms from wild land. This is entirely different from the gradual improvement of farms that are already "going concerns" in humid regions. No significant factor that influences soil management or farm economy should be left to chance in research for the improvement of known principles or for the discovery of new ones. By working in teams the effort of each scientific specialist can be expected to be ever so much more productive than if he works by himself.

Several important areas of needed soil research are the following:

1. Morphological study of the soils of relatively unexplored regions and their classification as a basis for preliminary reconnaissance mapping and appraisal. Previous soil experience has been highly concentrated on Alluvial soils and especially in areas easily reached by existing transport. Soil scientists have had inadequate opportunities to make detailed studies of arid soils remote from present population centers. Even in places where water is scarce, principles of great fundamental value to our knowledge of the formation and development of arid soils can be learned—principles important generally and to the stabilization and use of arid soils for grazing even though they cannot be irrigated.

2. Relation of soil permeability to drainage and salt removal. We need to know more precisely the lower limit of permeability, especially in subsoils and substrata, for satisfactory management with different kinds and amounts of irrigation water, the factors that control the permeability, and how permeability may be modified by chemical treatments, growing plants, and water management.

3. Development of structure and water-holding capacity in arid sandy soils through use of better adapted green-manuring crops, organic soil conditioners, or in other ways.

4. Better methods are needed for appraising the salt balance in whole watersheds where irrigation water is taken from streams and the drainage water is returned into the streams to be used again for irrigation at one or more lower levels.

5. More precise studies are needed of the soil properties that lead to chlorosis in plants and of ways to modify them.

6. The reasonable alternative combinations of plant nutrients, water supply, plant spacing, and cropping systems need to be tested in order to find the most nearly optimum ones for each kind of soil in terms of harvest, sets of practices, and the long-time effects on soil productivity. The results must be set forth in the specific terms required for calculating costs and input-output ratios needed in farm budgeting.

REFERENCES

1. BEAR, FIRMAN E., ed., 1949, Soil classification Soil Sci., 67, 77.
2. CROWTHER, FRANK, 1948, A Review of Experimental Work, Agriculture in the Sudan. (Tothill, J. D., ed.) Oxford Press, London, pp. 441-449.
3. FOURTH INTERNATIONAL CONGRESS OF SOIL SCIENCE, 1950, Transactions, Gronigen, Holland.
4. GREENE, H., 1948, Using Salty Land, Food and Agr., Organ of U.N., Agr. Studies No. 3, Washington.
5. IGNATIEFF, V., ed., 1949, Efficient Use of Fertilizers, Food and Agr., Organ of U.N., Agr. Studies No. 9, Washington and Rome. (Editions also in French and Spanish.)
6. KELLOGG, CHARLES E., 1941, The Soils that Support Us, Macmillan Co., New York.
7. KELLOGG, CHARLES E., 1948, Modern Soil Science. Amer. Sci., 36, 517, (Also in Science in Progress. (Baitsell, G. A., ed.) Ser. 6, Yale University Press, New Haven. 1949; and in the Smithsonian Report for 1949, Pub. No. 4004, Washington, 1950).
8. KELLOGG, CHARLES E., 1950, Food, Soil, and People, UNESCO, Food and People Ser. No. 6, Manhattan Publishing Co., New York.
9. KELLOGG, CHARLES E., 1951, Opportunities for World Abundance, Jour. of Politics, 13, 325.
10. KELLOGG, CHARLES E., 1951, Soil and Land Classification, Jour. Farm Econ., 33, 499.
11. REIFENBERG, A., 1947, The Soils of Palestine, Transl. by C. L. Whittles. Ed. 2, Murby, London.
12. RICHARDS, L. A., ed., 1947, Diagnosis and Improvement of Saline and Alkali Soils, U.S. Salinity Laboratory, Riverside, Calif. (Processed).
13. RUSSELL, SIR E. J., 1950, Soil Conditions and Plant Growth, Ed. 8, Longmans, London and New York. (Rev. by E. W. Russell).
14. SIMONSON, R. W., and WINTERS, ERIC, 1951, The Subsoil, Advances in Agronomy III (Norman, A. G., ed.), Academic Press, New York.
15. SMITH, JOE T., 1949, Development of Irrigation Farms with Special Reference to Irrigation and Crop Production under Desert Conditions as Observed in Saudi Arabia, U.N. Sci. Conf. on the Conserv. and Util. of Resources, New York, (Mimeographed).
16. SOIL SURVEY STAFF, 1951, Soil Survey Manual, U.S. Dept. Agr. Handbook No. 18, Washington.
17. STAFFORD, H. M., and HUBERTY, M. R., 1949, Soil Characteristics and Salinity in Relation to Irrigation and Drainage, U.N. Sci. Conf. on Conserv. and Util. Of Resources, New York (Mimeographed).
18. THORNE, D. W., and PETERSON, H. B., 1949, Irrigated Soils: Their Fertility and Management, Blakiston, Philadelphia.
19. TRUOG, EMIL, ed., 1951, Mineral Nutrition of Plants, Univ. Wis. Press, Madison, Wis.
20. WALLACE, T., 1951, The Diagnosis of Mineral Deficiencies in Plants by Visual Symptoms: A Colour Atlas and Guide, Ed. 2, H.M. Stationary Office, London.

INTERNATIONAL SYMPOSIUM ON DESERT RESEARCH, JERUSALEM, MAY 7 - 14, 1952

PROGRAMME OF MEETINGS AND LECTURESProgramme of Sessions

Morning Session:	9:00 A.M.	-	1:00 P.M.
Afternoon Session:	3:30 P.M.	-	6:00 P.M.
Evening Session:	8:00 P.M.	-	11:00 P.M.

7th, 8th, 9th, 10th of May - Jerusalem7th of May - Wednesday

Y.M.C.A. - Auditorium

Chairman: Dr. W. C. Lowdermilk, President of the Symposium

Welcoming and Introductory Addresses:

1. Mr. David Ben Gurion, Prime Minister of the State of Israel
2. The Mayor of Jerusalem
3. UNESCO Representative
4. Prof. M. Shwabe, Rector of the Hebrew University
5. Dr. W. C. Lowdermilk, President of the Symposium

8th of May - ThursdayMorning Session - - - INTRODUCTORY LECTURES FOR ALL SECTIONS

Y.M.C.A. - Auditorium

Chairman: Dr. W. S. Ladell (U.K.)

- | | |
|--|--------------------------------------|
| 1. "Dry Climates: Their Nature and Distribution" | ... Prof. J. B. Leighly (U.S.A.) |
| 2. "Potentialities and Problems of Arid Soils" | ... Dr. C. E. Kellogg (U.S.A.) |
| 3. "Biology and Arid Regions" | ... Prof. Th. Monod (France) |
| 4. "The Surface Movement of Blown Sand in Relation to Meteorology" | ... Dr. R. A. Bagnold, F.R.S. (U.K.) |

Afternoon Session - - - CLIMATE

Beth Halutzoth Assembly Hall

Chairman: Prof. J. B. Leighly (U.S.A.)

Section Secretary: Mr. M. Gilad (Israel)

- | | |
|---|--|
| 1. "Design and Use of Homo-climatic Maps" | ... Dr. P. Meigs (U.S.A.) |
| 2. "The Water Balance in Arid and Semi-Arid Areas" | ... Dr. C. W. Thornthwaite (U.S.A.) |
| 3. "Solar Radiation and Illumination Phenomena in Arid Zones" | ... Dr. D. Ashbel (Israel) - <i>Dr. Ashbel</i> |
| 4. "Dew Gradients as an Indication of Topography, Soil and Climate in Arid Areas" | ... Mr. S. Duvdevani (Israel) |

Evening Session - - - BIOLOGY

Beth Halutzoth Assembly Hall

Chairman: Dr. H. G. Thornton, F.R.S. (U.K.)

Section Secretary: Dr. H. Boyko (Israel)

- | | |
|---|--------------------------------------|
| 1. "The Physiology of Life and Work in High Ambient Temperatures" | ... Dr. W. S. Ladell (U.K.) |
| 2. Title to be confirmed | ... Dr. P. H. Newbitt (U.S.A.) |
| 3. "Problems of Animal Ecology and Physiology in Deserts" | ... Prof. F. S. Bodenheimer (Israel) |

9th of May - Friday

Morning Session - - - SOIL

Keren Hayesod Assembly Hall

Chairman - - - Prof. C. Aubert (France)

Section Secretary - - - Prof. A. Reifenberg
(Israel)

1. "Regional Geomorphic Patterns in relation to
Climatic Types in Dry Areas"

... Prof. Edwin S. Hills
(Australia)

2. "Floods in Deserts"

... Dr. W. C. Lowdermilk
(U.S.A.)

3. "The Struggle between the Desert and the
Sown" (with lantern slides)

... Prof. A. Reifenberg
(Israel)

Afternoon Session - - - SOIL (cont'd)

Keren Hayesod Assembly Hall

Chairman - - - Dr. R. A. Bagnold (U.K.)

1. "Problèmes Pédologiques de l'Irrigation des
Sols Arides dans le Delta Central Nigérien"

... Prof. G. Aubert (France)

2. "Classe du Chott Hodna parmi les Chotts
Algériens" (Gauthier)

... Prof. Ch. Killian (France)

3. "The Nature of the Soils of the Northern
Negev"

... Prof. S. Ravikovitz
(Israel)

Morning Session - - - BIOLOGY (cont'd)

Beth Halutzoth Assembly Hall

Chairman - - - Dr. B. T. Dickson (Australia)

1. "The Effect of Rain and Temperature on
Plant Distribution in the Desert"

... Dr. P. W. Went (U.S.A.)

2. "La végétation autour du Chott Hodna,
indicatrice des conditions culturelles"

... Prof. Ch. Killian (France)

3. "Some Aspects of Dry Zone Forestry"

... Sir Harold Glover, K.B. (U.K.)

4. "The Water Balance of Plants in Desert
Conditions"

... Prof. M. Even-Ari (Israel)

Afternoon Session - - - BIOLOGY (cont'd)

Beth Halutzoth Assembly Hall

Chairman - - - Prof. F. W. Went (U.S.A.)

1. "Plant Introduction"

... Dr. B. T. Dickson (Australia)

2. "Chemical components of useful or
potentially useful desert plants of
North America and the Industries derived
from them"

... Dr. Peter C. Duisberg (U.S.A.)

3. "Plant Biology of the Rajasthan (India)
Desert"

... Mr. Shanti Sarup (India)

4. "Problems of Soil Microbiology Relating
to Arid Regions"

... Dr. H. G. Thornton, F.R.S.
(U.K.)

10th of May - Saturday at 3:00 P.M.

Afternoon Session - - - GENERAL AND EXPLANATORY LECTURES

(presentation of papers without discussion)

Beth Halutzoth Assembly Hall

Chairman - - - Dr. C. E. Kellogg (U.S.A.)

- 3:20
3:45
3:45
4:02
1. Title to be confirmed ... Representative of the U.N. *ent*
 2. "Growth of World Population and Available Land Resources" ... Prof. Bonn  (Israel)
 3. "Nature and Extent of F.A.O.'s Ground Water Studies" ... Martin R. Huberty, F.A.O.

Chairman - - - Prof. Ardito Desio (Italy)

- 4:17
4:30
1. "The Catchment of Kurnub as an Experimental Station in the Negev" ... Mr. P.L.O. Guy (Israel)
 2. "Experimental Reservoir in the Negev" ... Mr. A. de Leeuw (Israel)

11th, 12th, 13th of May - - - EXCURSIONS IN THE NEGEV AND GALILEE

14th of May - Haifa

Morning Session - - - WATER and ENERGY

Hebrew Institute of Technology Lecture Hall

Chairman - - - Shri R. D. Dhir, I.S.E. (India)

Section Secretary - - - Mr. S. Irmay (Israel)

1. "The Measurement of Underground Water Discharges" ... Dr. P. Danel (France)
2. "Water Conducting and Retaining Properties of Soils in Relation to Irrigation" ... Dr. L. A. Richards (U.S.A.)
3. "The Application of Hydrologic Technique to Ground Water Problems in California's Central Valley" ... Mr. R. L. Boke (U.S.A.)
(paper presented by D. S. Stoner, U.S.A.)
4. "Aspects Divers de l'Hydrologie en Region Desertique" ... Dr. M. G. Drouhin (Algiers)

Afternoon Session - - - WATER and ENERGY (cont'd)

Chairman - - - Dr. P. Danel (France)

1. "Inter-relation of Surface and Ground Water with special reference to Arid Zones" ... Shri A. N. Khosla (India)
(paper presented by Shri R.D. Dhir, I.S.E., India)
2. "Prospecting for Underground Water in Israel" ... Prof. Y. L. Picard (Israel)
3. "Storage of Underground Water in Semi-Arid Regions" ... Prof. Ardito Desio (Italy)
4. "The Utilization of Wind Power" ... Mr. E. W. Golding (U.K.)

SYMPOSIUM ON DESERT RESEARCHPARTICIPANTS

<u>NAME</u>	<u>ADDRESS</u>
Aubert, G., Prof.	Chef du Service Office de la Recherche Scientifique d'Outre-Mer Paris 7 ^e <u>France</u>
Bacon, Mr.	Sudan Meteorological Service <u>Sudan</u>
Bagnold, R. A. Fr., F.R.S.	Royal Society London <u>England</u>
Calder, Ritchie	News Chronicle 12-22 Bouverie Street London, E.C. 4 <u>England</u>
Danel, P. Dr.	Laboratoire Dauphinois d'Hydraulique Grenoble, <u>France</u>
Dickson, B.T., Dr.	Commonwealth Scientific and Industrial Org. Canberra, A.C.T. <u>Australia</u>
Dhir, R.D., Shri (I.S.E.)	Director of Hydrology Central Water and Power Commission Government of India New Delhi <u>India</u>
Drouhin, M.G., Dr.	Directeur du Service de la Colonisation et de l'Hydraulique Alger <u>Algerie</u>
Golding, E. W.	The Electrical Research Association Savoy Place London, W. C. 2 <u>England</u>
Hills, Edwin S., Prof.	Dept. of Geology and Mineralogy University of Melbourne Victoria <u>Australia</u>
Killian, Ch. Prof.	Laboratoire de Botanique Expérimentale et Agricole <u>Alger</u>
Kellogg, C. E. Dr.	Chief, Division of Soil Survey U. S. Department of Agriculture Washington, D.C. <u>U.S.A.</u>
Lowdermilk, W.C. Dr.	Consultant of F.A.O. <u>Jerusalem</u>

SYMPOSIUM ON DESERT RESEARCH

PARTICIPANTS

<u>NAME</u>	<u>ADDRESS</u>
Leighly, J. B. Prof.	Department of Geography University of California Berkeley <u>U. S. A.</u>
Lidell, W. S. Dr.	Hot Climate Physiological Research Unit Lagos <u>Nigeria</u>
Llomas, Robert, Prof.	Director Institute Nacional de Biologia Chapultepec <u>Mexico</u>
Monod, Th., Prof.	Directeur de l'Institut Francais d'Afrique Noire Dakar <u>Afrique Occidentale Francaise</u>
Meigs, P. Prof.	International Geographical Union <u>U. S. A.</u>
Richards, L. A. Dr.	U. S. Salinity Laboratory <u>U. S. A.</u>
Thorntwaite, C. W. Dr.	The Johns Hopkins University Laboratory of Climatology Seabrook, N. J. <u>U. S. A.</u>
Thornton, H. S. Dr., F.R.S.	Rothamstead Experimental Station <u>England</u>
Went, F. W. Prof.	California Institute of Technology <u>U. S. A.</u>

SYMPOSIUM ON DESERT RESEARCHPARTICIPANTS

<u>NAME</u>	<u>ADDRESS</u>
Arbuthnot, J. B., Mr.	Public Health Engineer, W.H.O. W.H.O. & UNRWA Beirut <u>Lebanon</u>
Bedke, Hazen H. Lt. Col.	Company 2058th Air Weather Wing Wiesbaden, <u>Germany</u>
Birand, Hikmet, Prof.	University of Ankara Faculty of Science Ankara <u>Turkey</u>
Duisberg, Peter C. Dr.	Desert Products Co. Silver City New Mexico <u>U.S.A.</u>
Forsberg, Mr.	c/o Ministry of Agriculture Ankara <u>Turkey</u>
Frommurtz, Dr. H. F.	Ass't. Director Geological Survey of South Africa Pretoria <u>Union of South Africa</u>
Glover, Harold Sir	Late Chief Conservator of Forests, Punjab
Huberty, Martin R. Mr.	Representative of F.A.O. Rome <u>Italy</u>
Ireland, A. W.	Government Meteorologist Sudan Meteorologist Service Khartoum <u>Sudan</u>
Karaolmas, Adem	Ministry of Agriculture Ankara <u>Turkey</u>
Kranz, F. H. Cpt.	Company 2058th Air Weather Wing Wiesbaden <u>Germany</u>
Luino, G. Prof.	Inspector General of Agriculture Ispettorato Agrario Compartimentale per la Campania, Napoli, <u>Italy</u>
López de Llergo, Rita Miss	Director Institute of Geography University of Mexico <u>Mexico</u>

SYMPOSIUM ON DESERT RESEARCH

PARTICIPANTS

NAME

ADDRESS

Lockspeiser, Ben Sir

Secretary
Dept. of Scientific & Industrial Research
London
England

Malina, F. J. Dr.

Head, Division of Scientific Research
UNESCO
19, Avenue Kléber
Paris 16
France

Mason, H. Dr.

Institut des Hautes Etudes de Dakar
Dakar
Afrique Occidentale Française

Pond, Alonzo, M.A.

Chief, Desert Section
Maxwell Air Force Base
Alabama
U. S. A.

Purnell, E. Dr.

Middle-East Science Co-operation Office
c/o Teknik Universiteri
Gumussuyni,
Istanbul

Robaux, M. A.

Chef du Centre des Etudes Hydrogéologiques
Rabat
Maroc

Schoemaker, H. J. Mr.

Co-director of Hydraulic Laboratories
Delft
Holland

Shen Yi, Mr.

Chief, Bureau of Flood Control.
~~Head~~, UN Economic Commission for Asia and
the Far East
Bangkok
Thailand

Tixeront, Jean

Directeur des Travaux
Publics à Tunis
Tunis

Negre, R., Prof.

Institut Scientifique Chérifien
Rabat
Maroc

SYMPOSIUM ON DESERT RESEARCHSYMPOSIUMNAMEADDRESS

Prof. F. Bodenheimer

Hebrew University
Jerusalem
Israel

Prof. Bonne

Hebrew University
Jerusalem

Prof. L. A. Guy

Antiquities Department
Jerusalem

Mr. de Leeuw

Ministry of Agriculture
Jerusalem

Mr. S. Duvdevani

Desert Research Station
Karkur

Prof. S. Ravikovitz

Agricultural Research Station
Rehovot

Prof. A. Reifenberg

Hebrew University
Jerusalem

Dr. Kim

Hebrew University
Jerusalem

Prof. Y. L. Picard

Hebrew University
Jerusalem

PREPARATORY COMMITTEEDr. R. Bloch
Palestine Potash Co., Ltd.Prof. Y. L. Picard
Hebrew UniversityDr. H. Boyko
Ministry of AgricultureProf. S. Ravikovitz
Agricultural Research Station
RehovotProf. F. S. Bodenheimer
Hebrew UniversityProf. A. Reifenberg
Hebrew UniversityDr. M. Even Ari
Hebrew UniversityDr. Z. Rigbi
SerafenMr. M. Gilad
Meteorological Service
Ministry of TransportProf. S. Sambursky (Chairman)
Research Council of IsraelMr. S. Irmay
Hebrew Institute of TechnologyProf. W. Strauss
University-Hadassah Medical SchoolMr. de Leeuw
Ministry of AgricultureMiss S. Valero (Secretary)
Research Council of Israel

May 8

Early after breakfast I walk down to the YMCA for the first real day of papers of the Symposium. The YMCA is an unusually large fine building, really a great monument in the city of Jerusalem.

There is just a bit of confusion in getting started.

The first paper is Dry climates: their nature and distribution by Professor J. B. Leighly of the University of California. After his paper, the first questioner gives a long speech about the climate in Israel.

Next, I give my paper, Potentialities and problems of arid soils. It seems to go over all right. There are many questions and a lively discussion. Some of the questions deal with detail and specific schemes in Israel that I cannot answer. I find an opportunity, in reply to one question, to urge a scheme for the conservation of rainwater on the roofs within Jerusalem.

Professor Th. Monod of France reads a very long paper in French on Biology and arid regions.

Brigadier Bagnold of the U. K. reads an interesting paper on The surface movement of blown sand in relation to meteorology. He reads hesitatingly with no spirit -- characteristic of the stiff self-conscious Englishman.

I hurry back to the hotel for lunch and then again to the Symposium meetings at Beth Halutzoth assembly hall.

We have the following papers:

Design and use of homo-climatic maps by P. Meigs (U.S.A.),

The water balance in arid and semi-arid areas by

C. W. Thornthwaite (U.S.A.),

Dew gradients as an indication of topography, soil, and climate in arid areas by Mr. S. Duvdevani (Israel).

The papers are quite good. I doubt that many soil scientists will accept Thornthwaite's thesis that irrigation needs can be determined primarily from ^{weather} certain data alone. His material will be helpful in predicting general irrigation needs; but in deciding when and how much to irrigate in a particular field, special instruments are needed in the field.

After a hurried dinner, we go back for an evening session. The first paper is The physiology of life and work in high ambient temperatures by W. S. Ladell (U.K., Nigeria). This is a very good paper indeed.

Ladell confirmed from his researches many conclusions that I had reached in the Tropics from observation. He says a sun helmet is not needed. (I have found one useful in the heavy bush as a physical protection against branches of trees and vines.) He says that practically all cases of so-called heat prostration are really cases of sub-acute

alcoholism. The siesta is not good. People get a poor sleep in the warmest part of the day. It is better to work straight through the day and get a good sleep at night. It is better for health and to conserve scarce supplies of water to drink little and frequently than to drink heavily with long intervals between drinks.

Professor F. F. Bodenheimer (Israel) gives a paper on Problems of animal ecology and physiology in deserts.

I get to bed quite late. I take some part. He agrees with me that some of the best geomorphological research in Australia has in fact been done by the soil scientists, Butler, for example.

Dr. W. C. Lowdermilk presents Flora and deserts and makes quite a good point by emphasizing the study of geomorphology along with climate.

In his paper, The struggle between the desert and the sea, Professor Reifenberg (Israel) makes the point that many desert cities, of the Negev for example, were not supported primarily by farming but with money from the outside obtained from travelers and from the support of garrisons and monasteries. They did some gardening and farming around these desert towns but agriculture was not the main support.

May 9

We go to the morning session of the Symposium on Soil.

Today there are parallel sessions for soil and for biology.

Our meeting is in the building of the Jewish Agency.

Professor E. S. Hills of Melbourne gives an excellent paper on Regional geomorphic patterns in relation to climatic types in dry areas. This provokes a good deal of discussion about the climatic maps alone and the need for good maps of physiography and soils as well. I take some part. Hills agrees with me that some of the best geomorphological research in Australia has in fact been done by the soil scientists, Butler, for example.

Dr. W. C. Lowdermilk presents Floods and deserts and makes quite a good point by emphasizing the study of geomorphology along with climate.

In his paper, The struggle between the desert and the sown, Professor Reifenberg (Israel) makes the point that many desert cities, of the Negev for example, were not supported primarily by farming but with money from the outside obtained from travelers and from the support of garrisons and monasteries. They did some gardening and farming around these desert towns but agriculture was not the main support.

We hurry to lunch and then back to the afternoon session of three papers: Problèmes pédologiques de l'irrigation des sols arides dans le Delta Central Nigererien by Professor G. Aubert (France), Classe du Chott Hodna parmi les Chotts Algériens by Professor Ch. Killian (France), and The nature of the soils of the northern Negev by Professor S. Ravikovitz (Israel).

In all these sessions the rooms are very crowded. Many of the local people from Jerusalem and from the surrounding kibbutzim show a great interest in these sessions.

After the last paper we go to a reception and tea given to members of the Symposium by the faculty of Hebrew University in the YMCA. I am given about ten minutes notice that I shall be expected to reply to the greetings of the faculty on behalf of the foreign guests. After a welcoming speech by the Vice President and Professor Reifenberg, Dean of the science faculty, I speak roughly as follows:

"Mr. Vice President, we thank you for your description of the University. It is the spirit among the faculty and students that makes a great university. On behalf of my colleagues from other countries, I should like to take this opportunity to express our appreciation to the faculty, to the Research Council, and to the many scientists in Israel who are making our visits so pleasant."

I am sure that you can understand that some of us have not learned the details of your organization so I must speak to you as a group. First of all, I am highly complimented to have been included as one of your guests. Not only do we appreciate the opportunity to exchange views on scientific questions, but also to visit this Holy City which is the birthplace of so many ideas and institutions that are so important to people of good will everywhere.

Perhaps the most impressive of all to us is the eagerness and enthusiasm of the common people of this new state whom you are dedicated to serve.

Obviously they have great faith in science. They shall need help and guidance. This is your great obligation. You may be sure that all of us in other countries will be glad to help you in any way we can to fulfill this obligation. Such help at best will be small repayment for the great values we have already received.

Finally, Sir, we should ask you to offer our compliments to the officials of your government who have made this conference possible."

After this tea in the YMCA, Aubert, Dr. and Mrs. Richards, and I go with others to dinner with the Reifenberg.

We have much discussion about the University. I suggest that some danger exists that the faculty of the university

may become too academic and too isolated from the people, as in some European universities. Although vigorously denied by some of the faculty members, I believe the danger to be real. Some of the younger men in the university agree with me. Between 9 and 10:30 I have a discussion with Professor

As in Europe, conditions are a bit hard for the professional classes in Israel. There is strict rationing, strict controls of foreign exchange, lack of water for gardens, and so on. Then too, Arabs sneak through the lines at night to steal and murder.

Reifenberg is obviously nervous and tired. His physicians strongly advise against the field trip for him.

Brigadier Bagnold and I walk back to the hotel in a beautiful moonlight night. Probably because of the sabbath, one sees very few people on the street. Everything will be closed now until the next sundown. I am astonished that there are any programs at all for tomorrow.

Robert and I get our hotel bills paid.

After an early lunch I go again to the Pitha Hall, the assembly hall where I act as chairman of the Panel session in Jerusalem. I try to hurry the program along. The papers are given roughly as follows:

Growth of world population and available land resources
by Professor Bunch (Israel)

May 10

Aubert arose early for mass, so I get up early also for breakfast and to do a very difficult job of packing, to take one bag with me, and to send one directly to Haifa.

Between 9 and 10:30 I have a discussion with Professor Bonne', an economist of Hebrew University, about the problems of planning agricultural development in Israel. We discuss landlord-tenant relations, long-time agricultural investment, farm budgeting, detailed farm planning, and so on. I suggest the benefit of having a bright young economist interested in agriculture sent to work with Dr. Black at Harvard, and that one of Dr. Black's students return with him to start detailed analyses of representative kibbutzim, cooperative farms, and individual farms, in order to compare present organizations and efficiencies and to develop alternative organizations of greater intensity.

After some considerable discussion and corrections, Aubert and I get our hotel bills paid.

After an early lunch I go again to the Beth Halutzoth assembly hall where I act as chairman of the final session in Jerusalem. I try to hurry the program along. The papers are given roughly as follows:

Growth of world population and available land resources
by Professor Bonne' (Israel)

Nature and extent of FAO's ground-water studies
by Professor Martin Huberty (FAO-USA)

Appraising the prospective economic feasibility of
desert development projects by Mordecai Ezekiel (FAO),
summarized briefly by Professor Huberty

The catchment of Kurnub as an experimental station
in the Negev by Professor P.L.O. Guy (Israel)

Experimental reservoir in the Negev by Mr. A. de Leeuw
(Israel).

The paper reading is concluded about 4:30. I call
on a few for brief comments, but since the audience is
getting restless we close about 5:00.

I return to the hotel for a light supper and finish
packing. We are in the busses about 7 o'clock for Beersheba.
There is a bit of confusion when we leave about 7:50 p.m.,
first along the main road to Tel-Aviv. It is dusk as we
leave Jerusalem just after sundown. There are big crowds
on the streets and some of the shops are again open.

It is too dark to see anything along the road. We
arrive at army quarters in Beersheba about 10:30.

We are four to six in a room. I share a room with
Mr. Ireland, Mr. Calder, and Sir Ben Lockspeiser. We don't
get settled until nearly midnight.

STATE OF ISRAEL
MINISTRY OF TRANSPORT AND COMMUNICATIONS
METEOROLOGICAL SERVICE

Series A
METEOROLOGICAL NOTES No. 3

CLIMATOLOGICAL NORMALS

Part One



Decimal Index
551.582.2
(569.4)

JERUSALEM 1952

Published and printed by the Meteorological Service of the State of Israel

P R E F A C E

The need for climatological normals derived from standardized observations for agricultural and industrial research and planning has so often been expressed to us and requests for such data have been on such a scale during the last years that we have decided to publish climatological normals for selected stations.

Although, except for rainfall, these normals are being termed "preliminary" for reasons stated in the introduction, they may nevertheless serve as a sound basis for all those purposes where climatological data have to be taken into consideration.

Most of the data are derived from the stations of the late Palestine Meteorological Service; part of them has been obtained from the Meteorological Department of the Hebrew University, the Palestine Potash Ltd., and the Meteorological Office, Air Ministry, London.

The Normals have been prepared by the staff of the Climatological Division of this Service.

M. G i l e a d

Director Israel Meteorological Service

January 1952

C o n t e n t s

Table I : Mean monthly and annual rainfall	page 3
" II : " " rainfall as percentage of the annual total	" 9
" III : " number of rainy days	" 9
" IV : " Maximum Temperature	" 11
" V : " Minimum "	" 11
" VI : " Daily "	" 12
" VII : " " Range of Temperature	" 12
" VIII : Absolute Maximum "	" 14
" IX : " Minimum "	" 15
Comments on tables VIII and IX	" 16
Table X-Xa : Mean Relative Humidity	" 17-18
" XI : " Daily Evaporation	" 19
" XII-XIa : " Cloud Amount	" 20-21
Introduction	" 24

Erratum: The mean rainfall amount for October at Latrun (page 6) should be corrected to 15.6 mm.

INTRODUCTION

The tables contain normal values of annual and monthly rainfall amounts for 150 rainfall stations in the area of the former Mandate of Palestine, normals of the number of rainy days and the percentage distribution of rainfall-amounts month by month for 44 selected stations. Preliminary normals of temperature, relative humidity, cloudiness and evaporation are given for 21 meteorological stations in the country.

Standardized climatological observations—others than those of rainfall—obtained from a double-louvred screen, started in this country not before the years 1938—1940. Hence, the period 1940—1949 was used as the standard period for the computation of the normals—except those of rainfall. In consequence of the unsettled situation, even this period could not always provide coherent and homogeneous observations at all stations. In such cases the missing data had to be substituted by reduction to a suitable station. Except for the reduction of rainfall amounts for which use was made of the "quasi constancy" of quotients, the reduction of missing or unreliable data was based upon the "quasi constancy" of differences.* Stations, however, were only accepted for inclusion in the preliminary normals, when 6 years' complete and homogeneous observations were available (with the exception of Eilat, see below).

It may be argued that normals based upon a period of 10 years only, do not possess any great value and that conclusions reached in this way have little significance. In fact, a period of 30 years (1901—1930) was adopted by the International Meteorological Organisation as the standard period for climatological normals (Warsaw 1935). But owing to the frequent demands for preliminary normals for this country, it has, nevertheless, been thought useful to publish these data.

In order to indicate the fluctuations that may occur, table A shows the variation of 10 year-means of annual temperature during the period 1901—1940.

Variations at Beirut—the station nearest to our area with a long series of records—are placed between those at Greenwich (maritime climate) and those at Moscow (continental climate). [see (a) and (b) in table A.]

* Conrad V. and Pollak L. W. (1950). *Methods in Climatology*. 2nd ed. Cambridge, Mass. Harvard University Press. p. 238.

Table A: Variation of 10 year-means of annual temperature ($^{\circ}\text{C}$)

Period	Greenwich	Beirut	Moscow
1901-1930	9.9	21.1	3.7 (25 years only)
1901-1910	9.8	20.95	3.6
1911-1920	9.9	20.9	3.6 (5 years only)
1921-1930	10.1	21.5	3.9
1931-1940	10.2	21.6	4.7
(a) Sum of the deviations of the decade means from the mean 1901-30: 0.6 1.25 1.4			
(b) Absolute range of deviations: 0.4 0.7 1.0			

(The data have been obtained from: Clayton, H. H. (1927, 1934, 1947), World Weather Records. Washington, Smithsonian Misc. Collections, vols. 79, 90, 105).

Monthly normals are, of course, subject to larger variations. This point should be borne in mind, when using these preliminary normals. The fluctuations are smallest for the summer months and reach their maximum during the rainy season. The excess (or deficiency) of rain in a certain month may influence other climatological elements considerably; for example, mean temperatures in March for the period 1940-49 seem too low by 0.5°C — 1.5°C , compared with previous March normals and those of February and April of the decade 1940—49. In fact, the mean rainfall amount in March for this decade was at Jerusalem, for instance, the highest recorded for the whole period 1900—1949 (see table B). Consequently, temperature normals for March 1940—49 are relatively low and normals of cloudiness and relative humidity relatively high, compared with those resulting from a longer period of observations.

Table B: Mean rainfall amount (mm) in March at Jerusalem, Old City.

Period	1900-09	1910-19	1920-29	1930-39	1940-49
mm	64.0	99.6	40.4	46.1	106.5

With regard to rainfall amounts, a period of 10 years would have been too short in any case, both for computation of normal annual amounts and even more so of normal monthly amounts. For the 2 decades 1877—1886 and 1924—1938, for instance, the mean annual total at Jerusalem, Old City, varied from 649 mm to 419 mm.

Fortunately, several basic stations were at our disposal, at which the rainfall during the period 1901—1930 had been measured without interruption. Means of the basic stations were computed for this period and normals of the stations with a shorter series of observations obtained by reduction, using the principle

of the "quasi constancy" of quotients. Stations were included only, if at least 10 years' simultaneous records at both places were available.

With regard to the computation of the daily mean, we tried to find that conventional mean which approaches as near as possible the true daily mean.

It has been shown, that generally the daily mean temperature computed by the formula $(\text{maximum} + \text{minimum}) / 2$ deviates from the true daily mean less than the means computed with the aid of the temperatures at 08h, 14h and 20h—the local standard times of observations in use here; the formula $(\text{maximum} + \text{minimum}) / 2$, therefore, has been used for the computation of the normal daily mean temperature in these tables.

With regard to the other elements, it has been found that the arithmetic mean of the fixed time observations $(08h + 14h + 20h) / 3$ constitutes a fair working formula for an approximation of the true daily mean.* But it should be emphasized here, that for the daily mean of the relative humidity alternative formulae were found to give better results for some specified regions of this country; e.g. in the Jordan Valley (from Deganya to the Dead Sea), the mean daily relative humidity computed according to the formula $(08h + 14h) / 2$ deviates less from the true daily mean than that computed according to the other formulae. At Lydda - Airport, on the other hand, the formula $(08h + 14h + 2 \times 20h) / 4$ gives better results. Still, at most stations, the formula $(08h + 14h + 20h) / 3$ appears to fit best and, in order to achieve uniformity, it was used in these tables for the computation of the mean daily relative humidity for all stations. The same applies to the computation of the mean daily cloud amount; here, too, the formula $(08h + 14h + 20h) / 3$ has been used. It is hoped to give in a future publication monthly corrections for the conventional means of all elements at all stations, when more material for the determination of these corrections will have been assembled.

It has been thought worthwhile to add to the preliminary normals for 10 years the mean values of the respective climatological elements for Eilat as well. The material at our disposal, with the exception of rainfall observations, covers 4—5 years out of the period 1945-1951. This short period does not warrant a reduction to the standard period 1940—49; moreover, no suitable basic station for reduction was at our disposal. The unreduced means, therefore, are herewith published, in order to give those interested some idea of the climatological conditions prevailing at Eilat.

* Conrad V. and Pollak L. W. (1950). *Methods in Climatology*. 2nd ed. Cambridge, Mass. Harvard University Press. p. 164.

ט ב ל ה . X I I TABLE

Mean Cloud Amount (tenths) (בעשירות) כמות העננים הממוצעת

Period: 1940-49 תקופה:

Time : 2000* שעה:

.3

Mean of day ממוצע יומי .4

Month													חודש	Month													חודש		
שנה	XII	XI	X	IX	VIII	VII	VI	V	IV	III	II	I	STATION	התחנה	שנה	XII	XI	X	IX	VIII	VII	VI	V	IV	III	II	I		
Year															Year														
A. COASTAL REGION																												א. איזור החוף	
3.8	5.1	4.2	2.9	2.5	2.8	2.9	2.3	3.2	4.0	5.2	4.8	5.5	Acre	עכו	2.9	4.3	3.4	2.3	1.8	1.7	2.1	1.7	2.2	3.0	4.2	3.8	4.8		
3.8	5.7	4.2	3.0	2.3	2.4	2.2	2.3	3.6	4.1	5.2	4.9	5.5	Nafanya	נתניה	3.1	4.7	3.2	2.2	1.8	2.0	1.8	2.2	2.9	3.2	4.3	4.1	4.5		
3.5	5.3	4.2	2.8	2.1	1.9	1.9	1.7	3.3	3.9	5.1	4.8	5.1	Lydda, Airport	לוד, שדה התעופה	2.4	4.0	3.0	1.7	1.0	0.8	0.8	1.0	2.3	2.4	3.8	3.8	4.1		
2.7	4.4	3.3	2.0	1.4	1.3	1.2	1.2	2.4	2.9	4.2	4.0	4.2	Gaza	עזה	2.1	3.5	2.4	1.5	1.3	1.0	0.9	1.1	1.8	2.0	3.2	3.2	3.5		
B. HILL REGION																												ב. איזור ההרים	
3.4	5.5	4.2	2.9	1.5	1.1	1.0	1.1	3.1	3.9	5.4	5.1	5.6	Mt. Kena'an	הר כנען	2.3	4.6	3.2	1.8	0.5	0.2	0.2	0.4	1.8	2.7	4.0	3.9	4.7		
2.9	4.8	3.5	2.2	1.4	1.3	1.0	1.1	2.7	3.3	4.6	4.6	4.8	Tabor, Agr. School	תבור, ביד"ס החקלאי	1.9	3.6	2.3	1.2	0.4	0.4	0.4	0.5	1.7	1.9	3.2	3.3	3.8		
3.0	5.0	3.7	2.4	1.4	1.0	1.0	1.0	2.9	3.5	4.8	4.6	4.9	Heftsiyah Gilboa'	חפציבה, גלבוע	2.2	4.2	2.8	1.5	0.5	0.2	0.4	0.4	1.9	2.5	3.7	3.4	4.3		
3.4	5.3	3.9	3.0	2.2	1.4	1.4	1.5	2.9	3.9	5.4	5.0	5.3	Ramallah	רמאללה	2.6	4.0	2.7	2.0	1.8	0.9	1.0	1.2	2.2	3.1	4.4	4.1	4.4		
3.0	5.1	3.8	2.8	1.3	0.8	0.8	0.8	3.1	3.4	5.0	4.7	4.9	Jerusalem	ירושלים	2.2	4.1	2.9	1.8	0.5	0.4	0.3	0.6	2.3	2.2	3.9	3.6	4.0		
2.9	4.7	3.5	2.4	1.7	1.3	1.2	1.2	2.7	3.3	4.5	4.4	4.4	Beit Jimal	בית ג'ימל	2.2	3.8	2.8	1.9	1.2	0.8	0.7	0.9	2.0	2.4	3.4	3.3	3.8		
2.3	3.8	3.2	2.0	1.3	1.0	0.9	0.6	1.9	2.6	3.7	3.4	3.6	Beersheba	באר שבע	1.2	2.3	1.9	0.9	0.4	0.1	0.1	0.1	1.0	1.2	2.2	1.9	2.3		
C. THE RIFT VALLEY																												ג. שקע הירדן	
3.0	5.1	3.9	2.0	1.2	1.2	1.1	1.0	2.8	3.4	4.9	4.7	5.1	Tiberias	טבריה	1.9	3.8	2.4	1.2	0.3	0.1	0.1	0.3	1.5	2.1	3.3	3.3	4.0		
2.4	4.4	3.1	2.0	0.7	0.4	0.4	0.5	2.5	2.8	4.1	3.9	3.9	Jericho	יריחו	1.8	3.6	2.2	1.5	0.4	0.2	0.2	0.3	2.1	2.2	3.1	2.8	3.1		

* local standard time

*זמן מקומי תקין

ט ב ל ה ן ן X I T A B L E

Mean Cloud Amount (tenths) (בעשירות) כמות העננים הממוצעת

Time : 1400* : שעה

.2

Period: 1940-49 : תקופה

Time : 0800* : שעה

.1

Month													חודש														
שנה													שנה														
Year													Year														
XII XI X IX VIII VII VI V IV III II I													XII XI X IX VIII VII VI V IV III II I														
STATION													התחנה														
A. COASTAL REGION													א. איזור החוף														
3.9	5.4	4.2	3.0	2.2	2.7	3.0	2.3	3.3	4.1	5.3	5.3	6.1	Acre	עכו	4.5	5.7	4.9	3.4	3.4	4.1	3.5	2.9	4.0	4.8	6.0	5.3	5.7
3.7	6.2	4.5	3.2	1.9	1.6	1.4	1.5	3.4	4.2	5.3	5.3	6.2	Natanya	נתניה	4.6	6.2	4.9	3.7	3.1	3.7	3.5	3.1	4.6	5.0	5.9	5.4	5.9
3.7	6.1	4.8	3.4	2.0	1.1	1.0	0.9	3.2	4.2	6.0	5.6	5.9	Lydda, Airport	לוד, שדה התעופה	4.5	5.8	4.7	3.4	3.2	3.9	3.9	3.1	4.5	5.0	5.6	5.1	5.4
2.6	4.8	3.4	2.0	1.0	0.6	0.4	0.5	2.1	2.8	4.4	4.2	4.6	Gaza	עזה	3.4	4.8	4.0	2.4	1.9	2.4	2.4	2.1	3.4	3.9	4.9	4.7	4.4
B. HILL REGION													ב. איזור ההרים														
3.8	6.2	4.9	3.7	1.7	1.0	0.8	1.0	3.6	4.5	6.3	6.0	6.4	Mt. Kena'an	הר כנען	3.9	5.6	4.5	3.2	2.3	2.0	1.9	1.8	3.9	4.5	5.8	5.4	5.6
3.2	5.6	4.2	2.8	1.1	0.5	0.5	0.6	2.8	3.9	5.4	5.6	5.7	Tabor, Agr. School	תבור, ביד"ס החקלאי	3.7	5.2	4.1	2.7	2.6	3.0	2.2	2.1	3.6	4.2	5.2	4.9	5.0
3.3	5.6	4.3	3.0	1.2	0.5	0.7	0.7	3.1	4.2	5.6	5.3	5.5	Heftsibah, Gilboa'	חפציבה, גלבוע	3.6	5.1	3.9	2.6	2.4	2.3	2.0	1.8	3.7	3.9	5.0	5.0	5.0
3.8	6.2	4.8	3.7	2.0	1.1	1.0	1.1	3.2	4.5	6.2	5.7	6.1	Ramallah	רמאללה	3.9	5.7	4.3	3.4	2.8	2.3	2.1	2.1	3.4	4.1	5.7	5.3	5.5
3.6	5.9	4.5	3.5	1.6	0.9	1.0	0.9	3.8	4.3	5.8	5.6	5.8	Jerusalem	ירושלים	3.3	5.4	4.0	3.0	1.8	1.2	1.0	1.0	3.1	3.7	5.3	5.0	5.0
3.1	5.2	4.0	2.7	1.4	0.8	0.6	0.6	2.7	3.6	5.1	5.1	5.1	Beit Jimal	בית ג'ימל	3.5	5.0	3.7	2.6	2.4	2.4	2.2	2.0	3.3	3.9	5.0	4.7	4.4
2.7	4.7	4.0	2.6	1.1	0.6	0.4	0.3	2.2	3.1	4.7	4.4	4.7	Beersheba	באר שבע	3.1	4.5	3.6	2.5	2.4	2.2	2.1	1.5	2.6	3.6	4.2	3.9	3.7
C. THE RIFT VALLEY													ג. שקע הירדן														
3.3	5.7	4.7	2.1	1.0	0.5	0.4	0.7	3.2	4.1	5.8	5.6	6.0	Tiberias	טבריה	3.9	5.7	4.5	2.6	2.2	2.9	2.7	2.0	3.7	4.1	5.6	5.3	5.4
2.8	5.0	3.6	2.3	0.8	0.4	0.5	0.6	2.9	3.3	4.9	4.7	4.5	Jericho	יריחו	2.6	4.7	3.4	2.1	0.9	0.6	0.6	0.6	2.6	2.9	4.2	4.3	4.2

ט ב ל ה X I T A B L E

ההתאדות היומית הממוצעת ממדי-ההתאדות ל-Piche במ"מ עבור התקופה 1940-49.

Mean daily evaporation from Piche's evaporimeter in mm for period 1940 - 49.

תגורה Range	שנה Year	חודש Month												STATION	גובה (מ') Height (m)	רוחב Lat. ° N.	אורך Long. ° E.	ה ת ח ו ה
		XII	XI	X	IX	VIII	VII	VI	V	IV	III	II	I					
COASTAL PLAIN																		
1-7	4-7	4.0	5.3	5.7	4.7	4.2	4.4	4.8	5.5	4.7	4.4	4.1	4.2	Haifa, Mt. Carmel	300	32 48	34 59	מישור החוף
1-7	3-8	3.5	4.8	4.8	4.1	4.3	4.4	3.6	3.5	3.3	3.4	3.2	3.1	'Atilit	10	32 41	34 56	חיפה, הר הכרמל
2-0	5-0	4.0	5.7	6.0	5.2	4.9	5.0	5.1	5.6	5.2	4.4	4.0	4.5	Tel Shalom	70	32 28	34 59	עתלית
1-8	4-0	3.0	4.0	4.7	4.8	4.5	4.3	4.2	4.0	3.8	4.0	3.5	3.7	Natanya	35	32 20	34 51	תל שלום
1-9	4-6	3.7	4.4	5.4	5.6	5.1	4.8	4.7	4.2	4.3	4.6	4.0	4.4	Tel Aviv, Shore	5	32 06	34 47	נתניה
3-3	5-0	3.2	4.6	5.9	5.7	6.0	6.3	6.5	6.0	4.7	4.1	3.5	3.7	Lydda, Airport	40	32 00	34 54	תל אביב, חוף
1-8	4-4	3.2	3.9	4.9	5.0	4.7	4.6	4.7	4.8	4.5	4.6	4.1	3.6	Gaza	45	31 31	34 27	לוד, שדה התעופה
HILL REGION																		
6-3	6-4	3.6	6.0	7.4	7.0	8.4	9.3	9.2	9.1	6.3	4.1	3.5	3.0	Mt. Kena'an	935	32 59	35 30	עזה
5-8	6-5	3.5	5.8	7.5	7.7	8.7	9.3	9.3	8.7	5.8	4.0	3.6	3.7	Tabor, Agr. School	145	32 42	35 24	איזור ההרים
3-7	5-1	3.4	5.3	6.1	6.0	6.4	6.6	6.7	6.6	4.6	3.4	3.0	3.1	'Afula, Hospital	130	32 37	35 19	הר כנען
5-2	5-9	3.2	5.0	6.7	7.5	7.8	8.3	8.4	7.4	5.2	4.0	3.5	3.4	Mishmar ha 'Emeq	100	32 37	35 08	תבור, ביה"ס החקלאי
4-4	5-0	2.6	4.3	5.7	6.2	6.5	7.0	7.0	6.8	5.0	3.4	2.8	2.8	Jenin	140	32 28	35 18	עפולה, בית החולים
5-5	5-5	3.0	5.2	6.5	5.6	6.8	7.3	7.7	8.3	5.6	3.8	3.2	2.8	Ramallah	875	31 55	35 12	משמר העמק
2-8	4-9	3.5	4.7	5.5	4.8	5.6	6.1	6.1	6.3	4.8	4.1	3.9	3.8	Beit Jimal	360	31 43	34 59	ג'נין
5-9	6-4	3.4	5.1	7.0	7.0	7.9	8.7	9.1	9.3	6.7	4.7	4.4	3.9	Beersheba	270	31 14	34 47	רמאללה
JORDAN VALLEY																		
8-0	7-1	3.7	5.6	7.5	9.4	10.7	11.3	10.7	9.2	5.9	4.1	3.3	3.4	Tiberias	-110	32 48	35 32	בית ג'ימל
6-2	6-0	2.9	5.0	7.1	7.7	8.3	8.9	9.1	8.2	5.6	3.5	2.9	2.9	Beit Shean	-120	32 30	35 30	באר שבע
5-9	5-6	2.7	4.5	6.5	7.2	7.9	8.2	8.6	7.9	5.2	3.5	2.8	2.8	Heftsibah, Gilboa'	-80	32 31	35 26	שקע הירדן
6-9	6-8	3.4	5.1	7.4	8.4	9.5	10.3	10.3	9.1	6.6	4.4	3.7	3.8	Jericho	-260	31 51	35 27	טבריה
8-2	9-0	5.3	7.3	10.0	9.9	12.1	12.8	13.4	11.9	8.7	6.0	5.2	5.8	Dead Sea, North	-385	31 46	35 30	בית שאן
11-2	10-7	5.4	7.9	10.5	11.7	14.0	16.2	16.6	14.5	10.7	7.4	6.9	6.5	Dead Sea, South	-375	31 02	35 22	חפציבה, גלבוע
12-7	14-9	8.6	11.8	14.6	18.2	21.2	21.3	20.9	18.2	15.7	10.8	8.8	8.6	Eilat	3	29 33	34 58	יריחו
																		צפון ים המלח
																		דרום ים המלח
																		אילת

ט ב ל ה X TABLE

הלחות היחסית הממוצעת (%) Mean Relative Humidity
תקופה: 1940-49 Period:

ממוצע יומי Mean of day

שעה : 2000* Time : 3.

Month													חודש		STATION	התחנה	Month													חודש	
שנה Year	XII	XI	X	IX	VIII	VII	VI	V	IV	III	II	I	שנה Year	XII			XI	X	IX	VIII	VII	VI	V	IV	III	II	I				
A. COASTAL REGION													א. איזור החוף																		
67	67	62	60	64	69	70	68	68	68	67	69	67	Acre	עכו	73	73	69	67	71	76	78	77	77	76	74	73	71				
69	67	62	65	71	75	76	73	67	68	67	69	68	Haifa, Mt. Carmel	חיפה, הר הכרמל	75	71	70	71	78	83	84	81	74	74	72	72	70				
65	69	62	59	64	67	67	65	61	64	67	69	69	Tel Shalom	תל שלום	75	76	71	68	74	78	80	77	74	74	75	76	75				
73	74	70	69	73	75	78	75	75	74	73	73	71	Natanya	נתניה	78	78	76	74	79	81	84	81	81	80	77	76	74				
69	71	69	65	66	70	71	70	72	70	68	71	70	Tel Aviv, Shore	תל אביב, חוף	74	78	76	70	70	74	76	76	77	75	72	75	74				
64	70	64	58	60	62	62	58	58	64	68	71	70	Lydda, Airport	לוד, שדה התעופה	74	79	73	68	69	72	73	69	69	74	78	80	78				
70	73	72	68	68	70	72	70	70	69	67	70	70	Gaza	עזה	77	79	78	75	75	78	80	78	79	77	72	74	74				
B. HILL REGION													ב. איזור ההרים																		
58	73	57	52	57	51	47	45	44	57	69	73	76	Mt. Kena'an	הר כנען	63	76	62	60	68	57	51	51	47	60	73	75	78				
59	67	55	50	57	58	56	51	48	56	66	69	71	Tabor, Agr. School	תבור, ביד"ס החקלאי	66	72	62	58	66	69	66	60	56	65	73	74	75				
60	66	57	54	59	59	58	55	53	61	67	69	68	'Afula, Hospital	עפולה, בית החולים	70	71	66	64	69	71	72	69	66	73	74	75	73				
69	75	67	62	68	69	68	63	61	69	74	76	75	Mishmar ha 'Emeq	משמר העמק	79	81	77	72	80	82	81	77	73	80	82	82	81				
58	67	55	52	55	54	51	49	49	58	66	68	68	Heftsibah Gilboa'	חפציבה גלבוע	64	71	60	58	62	63	59	56	56	66	72	72	71				
58	68	57	51	55	55	54	50	48	56	67	69	67	Beit Shean	בית שאן	66	73	66	60	64	65	64	59	57	64	74	74	70				
61	69	60	55	59	58	55	53	52	61	66	71	69	Jenin	ג'נין	70	74	71	65	70	70	67	66	65	72	73	77	73				
63	73	61	56	65	61	58	53	49	60	70	72	74	Ramallah	רמאללה	74	79	69	69	82	80	75	68	60	70	76	78	78				
62	72	62	59	64	57	55	54	50	60	70	72	74	Jerusalem	ירושלים	73	79	73	72	77	71	68	66	61	69	77	79	79				
60	64	59	56	61	61	59	57	52	59	63	62	64	Beit Jimal	בית ג'ימל	72	72	70	69	77	78	75	72	66	71	72	70	70				
58	68	60	55	58	56	52	48	48	56	62	67	70	Beersheba	באר שבע	68	77	70	65	69	68	63	60	57	67	72	76	75				
C. THE RIFT VALLEY													ג. שקע הירדן																		
57	65	56	50	49	52	51	51	49	56	66	70	67	Tiberias	טבריה	60	67	60	53	52	56	54	53	53	60	69	72	69				
49	64	52	46	44	40	37	36	37	48	57	62	64	Jericho	יריחו	54	71	58	52	49	43	40	40	41	54	64	69	69				
39	49	45	42	37	30	28	29	34	35	44	48	50	Eilat	אילת	37	48	44	40	32	26	26	27	32	32	42	46	50				

ט ב ל ה X TABLE

הלחות היחסית הממוצעת (%) Mean Relative Humidity

תקופה: 1940-49 Period

שעה : 1400* Time

.2

שעה : 0800* Time

.1

חודש Month													STATION	ה ת ח נ ה	חודש Month												
שנה Year	XII	XI	X	IX	VIII	VII	VI	V	IV	III	II	I			שנה Year	XII	XI	X	IX	VIII	VII	VI	V	IV	III	II	I
A. COASTAL REGION														א. איזור החוף													
60	59	55	55	59	63	64	63	63	62	59	60	60	Acre	עכו	66	70	61	58	63	67	67	65	64	65	68	73	71
63	62	57	60	63	67	68	66	61	63	62	64	64	Haifa, Mt. Carmel	חיפה, הר הכרמל	68	69	60	63	71	75	75	72	66	66	66	70	69
55	59	52	49	54	58	56	55	50	55	56	57	60	Tel Shalom	תל שלום	66	73	63	59	64	66	65	62	60	64	71	73	72
67	66	62	62	67	69	72	70	70	69	66	65	63	Natanya	נתניה	75	78	72	71	74	76	77	74	73	74	76	78	76
63	60	61	61	62	66	68	66	69	65	61	62	60	Tel Aviv, Shore	תל אביב, חוף	70	76	70	64	65	69	70	69	70	69	70	75	75
50	55	51	47	50	51	50	47	44	50	52	54	54	Lydda, Airport	לוד, שדה התעופה	67	76	68	60	62	64	64	59	60	67	74	78	77
61	63	63	61	60	61	63	63	63	59	58	60	60	Gaza	עזה	72	78	75	69	70	71	72	68	68	71	71	75	76
B. HILL REGION														ב. איזור ההרים													
50	67	49	41	43	41	39	36	38	51	62	68	71	Mt. Kena'an	הר כנען	61	75	60	54	60	54	51	47	46	60	71	76	78
45	54	41	36	42	40	39	37	36	41	52	57	60	Tabor, Agr. School	תבור, ביה"ס החקלאי	65	74	61	57	62	64	62	56	53	62	72	77	78
45	54	41	37	42	40	39	37	36	46	52	55	56	'Afula, Hospital	עפולה, בית החולים	66	72	63	61	65	65	62	60	58	65	74	76	75
55	61	50	47	54	53	53	49	47	57	60	62	62	Mishmar ha 'Emeq	משמר העמק	73	82	74	67	70	71	69	64	64	71	79	83	81
44	54	42	37	39	38	38	34	36	44	52	55	56	Heftsiabah, Gilboa'	חפציבה, גלבוע	66	76	64	62	65	61	57	57	56	63	73	78	76
44	57	42	36	38	39	38	36	33	42	53	55	55	Beit Shean	בית שאן	65	74	64	56	62	62	60	56	53	63	74	78	77
47	57	43	39	44	43	42	38	38	48	53	59	59	Jenin	ג'נין	65	76	66	61	63	62	57	56	54	64	71	77	76
51	65	51	42	47	43	44	41	40	51	62	64	67	Ramallah	רמאללה	63	75	63	57	66	59	56	51	46	59	72	75	77
51	63	50	45	48	44	43	43	42	51	60	62	66	Jerusalem	ירושלים	63	75	64	59	66	57	54	52	48	59	72	74	77
47	55	47	43	45	43	41	42	38	46	52	52	56	Beit Jimal	בית ג'ימל	61	65	60	55	62	63	60	57	51	61	66	64	65
43	52	45	40	42	38	36	31	35	40	45	51	58	Beersheba	באר שבע	64	74	66	59	64	62	58	53	52	61	70	74	77
C. THE RIFT VALLEY														ג. שקע הירדן													
46	59	48	39	36	37	37	38	37	45	56	62	61	Tiberias	טבריה	64	69	61	57	60	62	61	61	58	62	72	76	71
37	50	40	34	32	29	27	27	27	36	44	48	50	Jericho	יריחו	56	72	59	52	52	48	45	42	44	54	64	70	72
30	38	35	32	27	23	21	22	27	27	33	35	39	Eilat	אילת	51	60	57	55	53	40	37	39	42	46	56	62	62

* local standard time

* זמן מקומי תקין

COMMENTS on tables VIII and IX.

In tables VIII and IX extreme temperatures recorded at selected stations are given irrespective of local exposure and of type of screen and thermometers used. In order to ensure a period of at least 20 years at most places, records from stations representing the same area have been combined; figures from Tel Aviv, for instance, comprise those of Tel Aviv City, Tel Aviv Shore, Jaffa (2 stations) and Sarona. Records of the following periods at the respective stations have been used for the compilation of the tables.

Acre: 1928—III. 1948.

Haifa: Haifa Town: 1900—08; 1921—VIII. 1941.

Haifa Airport: V. 1939—V. 1941; X.—XII. 1947; II.—III. 1948; VII. 1948—VII. 1951.

Kefar Ata: X. 1947—1951.

Tel Aviv: Jaffa: IX.—X. 1868; 1869. — I. 1870; XI. 1873—1874; VII. 1903—1913.

Sarona (Hakirya): IX. 1879—1889; VI. 1896; III. 1898—VI. 1899; 1900—03; VI. —VIII. 1948; 1949—51.

Tel Aviv City: IV. 1914—III. 1917; 1923—IX. 1943.

Tel Aviv Shore: VIII. 1939—1951.

Lydda—Ramle: Wilhelma: 1905—VI. 1913; IX. 1926—1937.

Ramle: 1921—40; VI. 1941—IV. 1942.

Lydda Airport: 1938—V. 1941; V. 1942—III. 1948; IV. 1949—1951.

Gaza: IV. 1869—IV. 1877; III. 1898—V. 1905; III. 1919—II. 1948.

Mt. Kena'an: 1939—51.

Beit Shean: 1930—III. 1948.

Jenin: 1921—47.

Jerusalem: Old City: XII. 1865—1914.

Prophets' Street: 1898—1912.

German Colony: X. 1895—1916.

Mt. of Olives: IV. 1918—XI. 1926.

American Colony: XII. 1926—III. 1935.

Palace Hotel: IV. 1935—1947.

Giv'at Shaul: V—VIII. 1948.

Talbiya: X. 1948—XII. 1949.

Generali Building: 1950—51.

Beit Jimal: 1920—1951.

Hebron: 1896—1914.

Beersheba: 1921—IX. 1938; VII. 1939—III. 1948; IV—VIII. 1949; XII. 1949—1951.

Tiberias: Old City: 1890—1911; II. 1939 — III. 1942.

Qiryat Shemuel: V. 1942—1951.

Jericho: 1921—III. 1948.

The highest temperature so far on record for the whole country was experienced during the period 19.—23. VI. 1942, in which a severe khamsin prevailed: on the 21st the thermograph at Tirat Tsevi (32° 25'N, 35° 31'E, height -220 m) registered 54 °C and on the 22nd the maximum thermometer at Kallia (31° 46'N, 35° 30'E, height -390 m) showed 51.2 °C. The lowest temperature ever recorded in Israel was measured during the period 5-7. II. 1950, in which snow on an unprecipitated scale covered almost the whole country: on the 7th the minimum thermometer at Tel ha Tanim (32° 48'N, 35° 18'E, height 150 m) showed -13 °C.

ABSOLUTE EXTREMES OF TEMPERATURE (°C)

TABLE IX טבלה ט

Absolute Minimum Temperature

טמפרטורת המינימום המוחלטת

STATION	שנה Year	XII	XI	X	IX	VIII	VII	VI	V	IV	III	II	I
COASTAL REGION													
Acre	1-2	2-0	5-2	10-2	13-0	15-1	15-5	11-7	7-5	4-2	1-2	1-4	1-5
Date	3-3-1928	27-1931	29-1932	26-1933	30-1938	15-1929	5-1932	10-1939	2-1932	2-1946	3-1928	25-1934	1-1937
Haifa	-2-5	0-5	6-7	8-5	16-4	18-5	17-4	13-4	10-0	4-5	1-2	-2-5	-1-6
Date	7-2-1950	31-1948	30-1948	15-1948	27-1949	22-1949	1-1948	8-1939	8-1941 1-1948	16-1941	2-1948	7-1950	25-1907
Tel Aviv	-1-1	-0-6	3-3	8-9	10-0	16-1	13-9	10-0	7-2	3-1	1-1	-1-0	-1-1
Date	25-1-1907 13-1-1910	31-1879	20-1908 21-1908	21-1874	29-1903	10-1913	1-1874	1-2-1874	3-1887 3-1905	2-1946	17-1880	7-1950	25-1907 13-1910
Lydda-Ramle	-2-3	1-6	3-7	9-2	11-5	15-2	14-4	10-0	6-4	0-5	0-0	-1-1	-2-3
Date	25-1-1907	26-1942	9-1907	31-1949	19-1905 30-1938	29-1906	5-1937	3-1943	2-1908	2-1946	2-1948	7-1950	25-1907
Gaza	-1-1	1-8	6-9	10-6	14-8	17-3	16-4	12-1	8-5	5-2	2-6	1-4	-1-1
Date	28-1-1925	28-1924	30-1932	27-1933	30-1938	19-1926	3-1933 16-1933 14-1934	3-1928	11-1921	2-1946	4-1928	18-1934	28-1925
HILL REGION													
Mt. Kena'an	-8-1	-0-5	3-9	9-0	11-4	13-2	12-5	9-4	6-2	0-6	-2-7	-8-1	-6-1
Date	6-2-1950	16-1951	20-1939	16-1941	30-1949	6-1940	1-1940	2-1943	5-1944	6-1943	6-1943	6-1950	5-1942
Jenin	-0-4	0-4	5-1	10-5	14-7	16-2	10-9	10-1	7-1	5-1	0-1	0-6	-0-4
Date	28-1-1925	27-1924	30-1929	19-1921	29-1938	8-1923	6-1922	29-1921	1-2-1921	5-1923	3-1928	8-1932	28-1925
Beisan	-0-5	0-6	5-4	10-4	13-5	17-1	17-0	12-0	8-0	2-8	0-5	1-0	-0-5
Date	26-1-1934	27-1933	28-1931	26-1933	30-1935	23-1947	2-1936	1-1937	6-1944	8-1943	3-1932	25-1934	26-1934
Jerusalem	-6-7	-5-0	-0-3	0-0	5-6	10-6	9-4	8-2	3-6	-1-1	-2-4	-4-4	-6-7
Date	25-1-1907	22-1905	14-1897	24-1871	17-1871 27-1871	26-28-31 1871	2-1871	8-1929	2-1887	6-1886	6-1943	6-1950	25-1907
Beit Jimal	-3-0	0-7	7-6	11-9	11-1	16-5	15-6	12-9	9-4	5-1	2-0	-1-5	-3-0
Date	27-1-1925	27-1924	8-1938	27-1924	12-1922	1-1926	15-1922	2-3-1943	1-1926	6-1949	3-1928	6-1950	27-1925
Hebron	-8-6	-5-8	-1-3	4-9	7-2	8-8	8-7	4-6	2-8	-0-6	-3-7	-2-9	-8-6
Date	29-1-1898	31-1897	18-1897	13-1903	27-1902	5-1900	6-1903 8-1904	2-1900	2-1897	3-1907	14-1910	17-1898	29-1898
Beersheba	-5-0	0-8	3-4	7-0	9-4	10-5	12-0	8-0	4-5	1-5	0-5	-4-0	-5-0
Date	31-1-1925	17-1932	30-1941	27-1933	17-1928 22-1930	2-1939	8-1923 13-1933 14-1933	3-1928	2-1932	2-1938	23-1945	7-1950	31-1925
JORDAN RIFT													
Tiberias	-3-3	-3-3	4-4	10-0	10-0	13-3	17-0	13-8	9-4	6-1	3-9	-0-5	-3-3
Date	27-12-1898 31-12-1898 21-1-1911	27-1898 31-1898	19-1908	14-1898 15-1898	19-1894	9-1898	21-1939	5-1939	6-9-1898	11-1896 10-1898 11-1898	21-1898	6-1950	21-1911
Jericho	1-3	2-2	8-0	13-4	17-0	19-6	19-0	15-0	10-0	6-5	1-5	2-6	1-3
Date	6-1-1942	27-1933	30-1932 30-1941	22-1941	18-1932 21-1936	5-1944	29-1927	1-1926	11-1923	8-1943 2-1946	3-1928	9-1932	6-1942

ערכים קיצוניים מחלטים של הטמפרטורה (°C)

TABLE VIII ט ב ל ה

Absolute Maximum Temperature

טמפרטורת המקסימום המחלטה

שנה Year	XII	XI	X	IX	VIII	VII	VI	V	IV	III	II	I	ה ת ח נ ה
44.7 5.5.1942	29.5 5.1939	36.5 6.1941	42.0 2.1943	43.5 15.1931	33.5 6.1941	35.7 17.1947	43.0 2.1940	44.7 5.1942	42.6 25.1928	34.3 28.1928	31.2 23.1941	27.1 18.1948	עכו תאריך
44.6 10.5.1941	29.4 19.1937	36.0 15.1933 2.1948 6.1949	41.4 4.1940	41.8 27.1929	37.1 8.1931	35.9 16.1951	42.8 2.1940	44.6 10.1941	42.5 22.1928	40.0 25.1934	30.4 27.1929	26.7 18.1948	חיפה תאריך
46.5 17.5.1916	32.2 3.1879	35.6 4.1880	41.5 1.1943	42.0 30.1943	41.1 27.1881	35.6 1.1884	44.4 15.1886	46.5 17.1916	40.0 25.1928	37.5 27.1913	30.0 2.1912	26.7 17.1881 18.1881	תל אביב תאריך
47.0 15.5.1927 13.6.1933	33.2 30.1927	37.2 10.1933	43.3 2.1943	42.2 14.1931 30.1943	41.0 1.1928	42.0 10.1912	47.0 13.1933	47.0 15.1927	46.8 24.1928	37.7 18.1925	32.7 24.1941	27.8 3.1934	לוד - רמלה תאריך
46.7 26.5.1873	32.5 19.1937	39.1 6.1941	42.4 3.1943	42.2 27.1929	37.8 3.1872	38.3 3.1926	44.2 9.1933	46.7 26.1873	43.1 22.1928	39.1 18.1925	34.4 29.1924	30.0 1.1870	עזה תאריך

איזור החוף

איזור ההרים

40.0 22.6.1942	21.6 4.1943	30.1 2.1941	35.6 2.3.1943	36.0 8.1946	34.9 2.1945	38.1 11.1945	40.0 22.1942	36.8 24.1939 11.1941	31.4 27.1944	25.9 24.1951	26.7 23.1941	19.9 18.1948	הר כנען תאריך
47.2 22.6.1942	29.1 1.1925	36.6 6.1922	42.0 2.1943	42.9 4.1923	41.7 9.1930	42.1 21.1932	47.2 22.1942	45.6 10.1941	42.8 24.1928	34.3 28.1922 18.1925	31.3 18.1932	27.6 3.1934	ג'נין תאריך
48.0 15.9.1931	29.9 4.1943	37.5 1.1933	42.8 1.1943	48.0 15.1931	42.5 9.1930 14.1936	45.2 11.1945	47.8 22.1942	45.5 23.1931	42.3 23.1936	36.5 27.1947	30.5 18.1933	27.0 3.1934	בית שאן תאריך
44.4 28.8.1881 30.8.1881	27.0 4.1879	32.2 2.3.1941	36.7 4.1943	41.1 16.1902	44.4 28.1881 30.1881	41.1 12.1888 13.1888	42.2 18.1894	39.6 11.1941	39.1 24.1928	33.1 31.1901	29.9 23.1941	25.2 29.1935	ירושלים תאריך
44.9 13.6.1933	30.4 17.1937	37.7 7.1936	41.8 4.1943	43.6 18.1931	38.2 24.1924 25.1924	40.0 11.1924	44.9 13.1933	44.0 6.1942	43.6 24.1928	34.7 21.1932	34.1 23.1941	28.8 13.1931	בית ג'ימל תאריך
40.3 13.7.1913	25.6 2.1900	29.7 3.1901	37.2 25.1897	38.6 2.1910 15.1913	39.5 13.1896 22.1910	40.3 13.1913	39.5 1.1914	38.1 31.1909	34.4 26.1901	33.3 29.1901	25.6 19.1901	24.4 7.1907	חברון תאריך
46.0 13.6.1933	32.2 18.1937	38.3 3.1941	41.6 3.1943	43.8 18.1931	41.5 13.1921	42.0 11.1924	46.0 13.1933	44.7 1.2.1935 10.1941	43.8 30.1935	36.5 31.1924 18.1925	35.2 23.1941	30.3 29.1935	באר שבע תאריך

שקע הירדן

49.0 21.6.1942	31.1 7.8.1891 13.1892	37.1 2.1944	44.6 4.1940	45.6 15.1902 16.1902	44.4 13.1896	46.1 11.1945	49.0 21.1942	47.5 10.1941	41.1 26.1944	36.1 26.1899	33.3 17.1902	27.1 5.1941	טבריה תאריך
50.5 22.6.1942	30.2 14.1947	37.3 3.1926	45.4 2.1943	47.0 18.1931	47.0 23.1924	45.6 11.1926	50.5 22.1942	48.8 16.1927	47.0 24.1928	38.2 31.1940	31.6 20.1941	29.0 2.1934	יריחו תאריך

באורים לסבלות VIII ו-IX.

בטבלות VIII ו-IX מובאים ערכי הטמפרטורות הקיצוניות שנרשמו עד כה בתחנות גבחרות מבלי להתחשב בשינויים שחלו במשך הזמן במקום הצבתן ובסוג הסוכה והתרמיטרים. על מנת להקיף תקופות לפחות של 20 שנה במרבית המקומות, נבחרו הערכים הקיצוניים של סביבה מסוימת מתוך נתוני כל התחנות השונות שהיו קימות בה. כך, למשל, נבחרו הטמפרטורות הקיצוניות עבור תל אביב מתוך המדידות שנערכו בעיר תל אביב, בחוף תל אביב, ביפו (2 תחנות) ובשרונה. והרי רשימת התחנות והתקופות שסוכם בטבלות הנ"ל:

עכו: 1928—III. 1948.

חיפה: העיר חיפה: 1900—1908; VIII. 1921—1941.

שדה התעופה של חיפה: V. 1939—V. 1941; X—XII. 1947; II—III. 1948; VII. 1948—VII. 1951.

כפר אתא: X. 1947—1951.

תל אביב: יפו: IX—X. 1868; 1869 — I. 1870; XI. 1873—1874; VII. 1903—1913.
שרונה (הקריה): IX. 1879—1889; VI. 1896; III. 1898—VI. 1899; 1900—1903;
VI. 1948—VIII. 1949; 1951.

העיר תל אביב: IV. 1914—III. 1917; IX—1923. 1943.

חוף תל אביב: VIII. 1939—1951.

לוד—רמלה: וילהלמה: 1905—VI. 1913; IX. 1926—1937.

רמלה: 1921—1940; VI. 1941—IV. 1942.

לוד, שדה התעופה: 1938—V. 1941; V. 1942—III. 1948; IV. 1949—1951.

עזה: IV. 1869—IV. 1877; III. 1898—V. 1905; III. 1919—II. 1948.

הר כנען: 1939—1951.

בית שאן: 1930—III. 1948.

ג'נין: 1921—1947.

ירושלים: העיר העתיקה: XII. 1865—1914.

רחוב הנביאים: 1898—1912.

המושבה הגרמנית: X. 1895—1916.

הר הזיתים: IV. 1918—XI. 1926.

המושבה האמריקאית: XII. 1926—III. 1935.

מלון פלס: IV. 1935—1947.

גבעת שאול: V—VIII. 1948.

טלביה: X. 1948—XII. 1949.

בנין ג'נרלי: 1950—1951.

בית ג'ימל: 1920—1951.

חברון: 1896—1914.

באר שבע: IX—1921; VII. 1938; III—1948; IV—VIII. 1949; XII. 1949—1951.

טבריה: העיר העתיקה: 1890—1911; II. 1939—III. 1942.

קרית שמואל: V. 1942—1951.

יריחו: 1921—III. 1948.

הטמפרטורה הגבוהה ביותר שנרשמה עד כה בכל ארץ ישראל ארעה בתקופה 19—VI. 23, 1942, בה שרר חמסין קשה: בתאריך ה-21 רשם התרמוגרף בטירת צבי (220° מ' מפני הים) טמפרטורה של 54° C, וביום ה-22 הראה תרמומטר המקסימום בקליה (390° מ' מפני הים) 51.2° C. הטמפרטורה הנמוכה ביותר שנרשמה אי פעם בישראל ארעה בשילוב עם השלג מימי 5-7. II. 1950 שכיסה כמעט את פני כל הארץ ואשר טרם נודע כמותו: בתאריך ה-7 הראה תרמומטר המינימום בתל התנים שבבקעת בית גטופה טמפרטורה של 13°- C.

ט ב ל ה TABLE VII

תנודה יומית ממוצעת של הטמפרטורה (°C) Mean Daily Range of Temperature

תקופה: 1940 - 49 Period:

שנה	חודש												Month
Year	XII	XI	X	IX	VIII	VII	VI	V	IV	III	II	I	

A. COASTAL REGION

9.5	9.0	10.7	10.9	9.2	8.3	8.2	8.8	10.1	10.6	10.0	9.5	8.5	Acre
6.8	5.9	6.6	7.1	6.2	6.2	6.4	7.1	8.3	7.6	7.3	7.0	6.0	Haifa, Mt. Carmel
9.9	8.0	10.1	11.1	9.8	9.6	9.8	10.5	11.6	11.1	9.6	9.3	8.6	Tel Shalom
9.0	8.9	10.1	9.9	8.7	8.2	7.8	8.4	9.5	9.4	9.2	8.9	8.6	Natanya
9.6	9.8	11.0	10.9	9.7	8.7	8.6	9.2	9.6	9.8	9.3	9.3	9.4	Tel Aviv, Shore
12.5	11.0	13.0	13.5	11.9	11.8	12.1	13.4	14.8	13.7	12.2	11.8	10.7	Lydda, Airport
10.4	9.6	10.5	11.4	10.5	10.7	10.6	10.8	11.0	10.5	10.3	9.9	9.5	Gaza

B. HILL REGION

8.5	5.4	7.1	9.3	10.8	10.8	10.5	10.8	9.9	9.1	7.1	6.2	5.4	Mt. Kena'an
11.7	9.0	11.8	13.2	12.1	12.1	12.2	13.1	14.2	13.2	10.8	9.6	8.8	Tabor, Agr. School
11.9	9.0	12.0	13.3	12.6	12.5	12.8	13.6	14.3	13.0	10.7	10.0	9.0	'Afula, Hospital
11.6	10.4	13.2	13.9	11.6	10.2	10.5	11.7	13.3	13.3	11.3	10.5	10.0	Mishmar ha 'Emeq
12.7	10.1	12.7	14.0	12.9	12.7	13.0	14.0	15.2	14.5	12.2	11.3	10.2	Heftsiyah, Gilboa'
13.5	10.6	13.4	14.6	14.4	14.2	14.5	15.0	15.6	15.2	12.9	11.7	10.4	Beit Shean
11.6	9.1	11.1	12.6	12.0	12.2	12.8	13.3	14.0	12.4	10.7	9.7	9.1	Jenin
9.4	6.2	7.8	10.0	11.0	11.6	11.4	11.7	11.2	9.5	8.1	7.4	6.5	Ramallah
9.8	7.1	8.5	10.2	11.2	11.5	11.2	11.7	11.2	10.4	8.9	8.1	7.2	Jerusalem
10.1	7.4	8.9	10.5	11.1	11.8	11.9	12.2	12.2	11.0	9.1	8.2	7.4	Beit Jimal
13.6	11.0	13.0	14.8	14.6	15.3	14.8	15.3	15.5	14.4	12.0	12.1	10.8	Beersheba

C. THE RIFT VALLEY

10.4	7.1	9.1	10.9	11.5	11.7	12.0	12.7	13.1	11.8	9.5	8.6	7.4	Tiberias
13.3	10.2	12.5	14.0	14.2	14.5	15.2	15.5	15.2	14.5	12.4	11.3	10.3	Jericho
13.1	12.0	12.5	12.5	13.0	14.7	14.2	15.0	13.5	13.6	13.0	12.3	11.2	Eilat

ט ב ל ה TABLE VI

טמפרטורה יומית ממוצעת (°C) Mean Daily Temperature

תקופה: 1940 - 49 Period:

שנה	חודש												Month
Year	XII	XI	X	IX	VIII	VII	VI	V	IV	III	II	I	

א. איזור החוף

19.9	15.4	20.0	22.8	24.9	25.4	25.7	23.6	21.0	17.3	14.8	13.8	13.6	עכו
18.8	13.8	19.4	22.2	23.9	24.9	24.3	22.6	20.4	16.9	13.6	12.2	11.9	חיפה, הר הכרמל
19.9	15.1	20.0	23.2	24.9	26.0	25.4	23.8	21.6	17.6	14.8	13.4	13.1	תל שלום
19.7	15.0	19.6	22.8	25.0	25.9	25.1	23.4	20.6	17.1	14.8	13.6	13.5	נתניה
19.1	14.7	18.7	21.6	24.0	25.4	24.7	22.6	20.0	16.5	14.6	13.2	13.2	תל אביב, חוף
19.5	14.6	19.0	22.6	24.6	26.0	25.4	23.6	21.3	17.0	14.3	13.0	12.8	לוד, שדה התעופה
20.1	15.4	19.8	22.9	25.2	26.2	25.7	23.8	21.3	18.0	15.8	14.0	13.6	עזה

ב. איזור ההרים

16.1	9.3	15.4	19.4	22.0	23.8	23.6	22.0	19.8	14.0	9.4	7.8	7.1	הר כנען
20.5	14.3	19.9	23.8	26.2	27.8	27.4	25.6	23.1	18.2	14.2	12.8	12.2	תבור, ביה"ס החקלאי
20.6	14.6	20.2	24.0	26.2	27.6	27.2	25.5	23.0	18.3	14.6	13.2	12.6	עפולה, בית החולים
19.8	13.6	19.1	23.0	25.6	26.9	26.4	24.6	22.2	17.4	14.0	12.8	12.0	משמר העמק
21.9	15.4	21.0	25.2	28.0	29.6	29.3	27.4	24.8	19.6	15.5	14.0	13.4	חפציבה, גלבוע
21.7	15.1	20.8	24.8	27.8	29.3	29.0	27.3	25.0	19.6	15.2	13.6	13.3	בית שאן
20.4	14.0	19.4	23.5	26.0	27.6	27.0	25.6	23.2	18.3	14.6	12.8	12.4	ג'נין
16.4	10.5	16.1	19.6	21.6	23.2	22.8	21.4	19.6	14.6	10.4	8.9	8.4	רמאללה
17.1	11.0	16.6	20.3	22.2	23.8	23.5	22.2	20.7	15.5	11.2	9.6	8.8	ירושלים
20.2	14.9	20.0	23.6	25.2	26.6	26.2	24.7	22.9	18.1	14.6	13.3	12.8	בית ג'ימל
19.5	13.5	18.5	22.0	24.2	26.0	26.2	24.6	22.8	17.9	14.0	12.4	11.6	באר שבע

ג. שקע הירדן

22.9	16.4	22.0	26.2	29.0	30.8	30.5	28.6	26.0	20.6	16.4	14.6	14.1	טבריה
23.7	16.7	22.2	26.8	29.6	31.2	31.2	29.6	27.2	22.0	17.6	15.8	15.0	יריחו
24.8	17.4	22.4	26.6	30.9	33.0	32.5	30.7	28.6	24.3	19.5	16.2	15.3	אילת

טבלה V TABLE V

Mean Minimum Temperature (°C) טמפרטורת המינימום הממוצעת

תקופה: 1940 - 49 Period:

חודש Month												STATION	ה ת ח נ ה
XII	XI	X	IX	VIII	VII	VI	V	IV	III	II	I		

A. COASTAL REGION א. איזור החוף

10.9	14.6	17.3	20.3	22.3	21.6	19.2	15.9	12.0	9.8	9.0	9.4	Acre	עכו	19.9	25.3	28.2	29.5	30.6	29.8	28.0	26.0	22.6	19.8	18.5	17.9
10.9	16.1	18.6	20.8	21.8	21.1	19.0	16.3	13.1	10.0	8.7	8.9	Haifa, Mt. Carmel	חיפה, הר הכרמל	16.8	22.7	25.7	27.0	28.0	27.5	26.1	24.6	20.7	17.3	15.7	14.9
11.1	15.0	17.7	20.0	21.2	20.5	18.6	15.8	12.1	10.0	8.8	8.8	Tel Shalom	תל שלום	19.1	25.1	28.8	29.8	30.8	30.3	29.1	27.4	23.2	19.6	18.1	17.4
10.6	14.6	17.9	20.6	21.8	21.2	19.2	15.9	12.4	10.2	9.2	9.2	Natanya	נתניה	19.5	24.7	27.8	29.3	30.0	29.0	27.6	25.4	21.8	19.4	18.1	17.8
9.8	13.2	16.2	19.1	21.0	20.4	18.0	15.2	11.6	9.9	8.6	8.5	Tel Aviv, Shore	תל אביב, חוף	19.6	24.2	27.1	28.8	29.7	29.0	27.2	24.8	21.4	19.2	17.9	17.9
9.1	12.5	15.8	18.7	20.1	19.4	16.9	13.9	10.1	8.2	7.1	7.5	Lydda, Airport	לוד, שדה התעופה	20.1	25.5	29.3	30.6	31.9	31.5	30.3	28.7	23.8	20.4	18.9	18.2
10.6	14.5	17.2	19.9	20.8	20.4	18.4	15.8	12.7	10.6	9.0	8.8	Gaza	עזה	20.2	25.0	28.6	30.4	31.5	31.0	29.2	26.8	23.2	20.9	18.9	18.3

B. HILL REGION ב. איזור ההרים

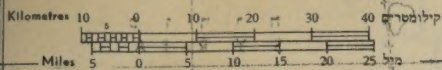
6.6	11.9	14.8	16.6	18.4	18.4	16.6	14.8	9.4	5.9	4.7	4.4	Mt. Kena'an	הר כנען	12.0	19.0	24.1	27.4	29.2	28.9	27.4	24.7	18.5	13.0	10.9	9.8
9.8	14.0	17.2	20.1	21.7	21.3	19.0	16.0	11.6	8.8	8.0	7.8	Tabor, Agr. School	תבור, ביה"ס החקלאי	18.8	25.8	30.4	32.2	33.8	33.5	32.1	30.2	24.8	19.6	17.6	16.6
10.1	14.2	17.3	19.9	21.4	20.8	18.7	15.9	11.8	9.3	8.2	8.1	'Afula, Hospital	עפולה, בית החולים	19.1	26.2	30.6	32.5	33.9	33.6	32.3	30.2	24.8	20.0	18.2	17.1
8.4	12.5	16.0	19.8	21.8	21.1	18.8	15.5	10.8	8.4	7.5	7.0	Mishmar ha 'Emeq	משמר העמק	18.8	25.7	29.9	31.4	32.0	31.6	30.5	28.8	24.1	19.7	18.0	17.0
10.3	14.7	18.2	21.5	23.3	22.8	20.4	17.2	12.4	9.4	8.3	8.3	Heftsibah, Gilboa'	חפציבה, גלבוע	20.4	27.4	32.2	34.4	36.0	35.8	34.4	32.4	26.9	21.6	19.6	18.5
9.8	14.1	17.5	20.6	22.2	21.8	19.8	17.2	12.0	8.7	7.8	8.1	Beit Shean	בית שאן	20.4	27.5	32.1	35.0	36.4	36.3	34.8	32.8	27.2	21.6	19.5	18.5
9.4	13.9	17.2	20.0	21.5	20.6	18.9	16.2	12.1	9.2	8.0	7.8	Jenin	ג'נין	18.5	25.0	29.8	32.0	33.7	33.4	32.2	30.2	24.5	19.9	17.7	16.9
7.4	12.2	14.6	16.1	17.4	17.1	15.6	14.0	9.9	6.3	5.2	5.1	Ramallah	רמאללה	13.6	20.0	24.6	27.1	29.0	28.5	27.3	25.2	19.4	14.4	12.6	11.6
7.4	12.3	15.2	16.6	18.1	17.9	16.3	15.1	10.3	6.7	5.5	5.2	Jerusalem	ירושלים	14.5	20.8	25.4	27.8	29.6	29.1	28.0	26.3	20.7	15.6	13.6	12.4
11.2	15.6	18.3	19.7	20.7	20.2	18.6	16.8	12.6	10.0	9.2	9.1	Beit Jimal	בית ג'ימל	18.6	24.5	28.8	30.8	32.5	32.1	30.8	29.0	23.6	19.1	17.4	16.5
8.0	12.0	14.6	16.9	18.4	18.8	16.9	15.0	10.7	8.0	6.3	6.2	Beersheba	באר שבע	19.0	25.0	29.4	31.5	33.7	33.6	32.2	30.5	25.1	20.0	18.4	17.0

C. THE RIFT VALLEY ג. שקע הירדן

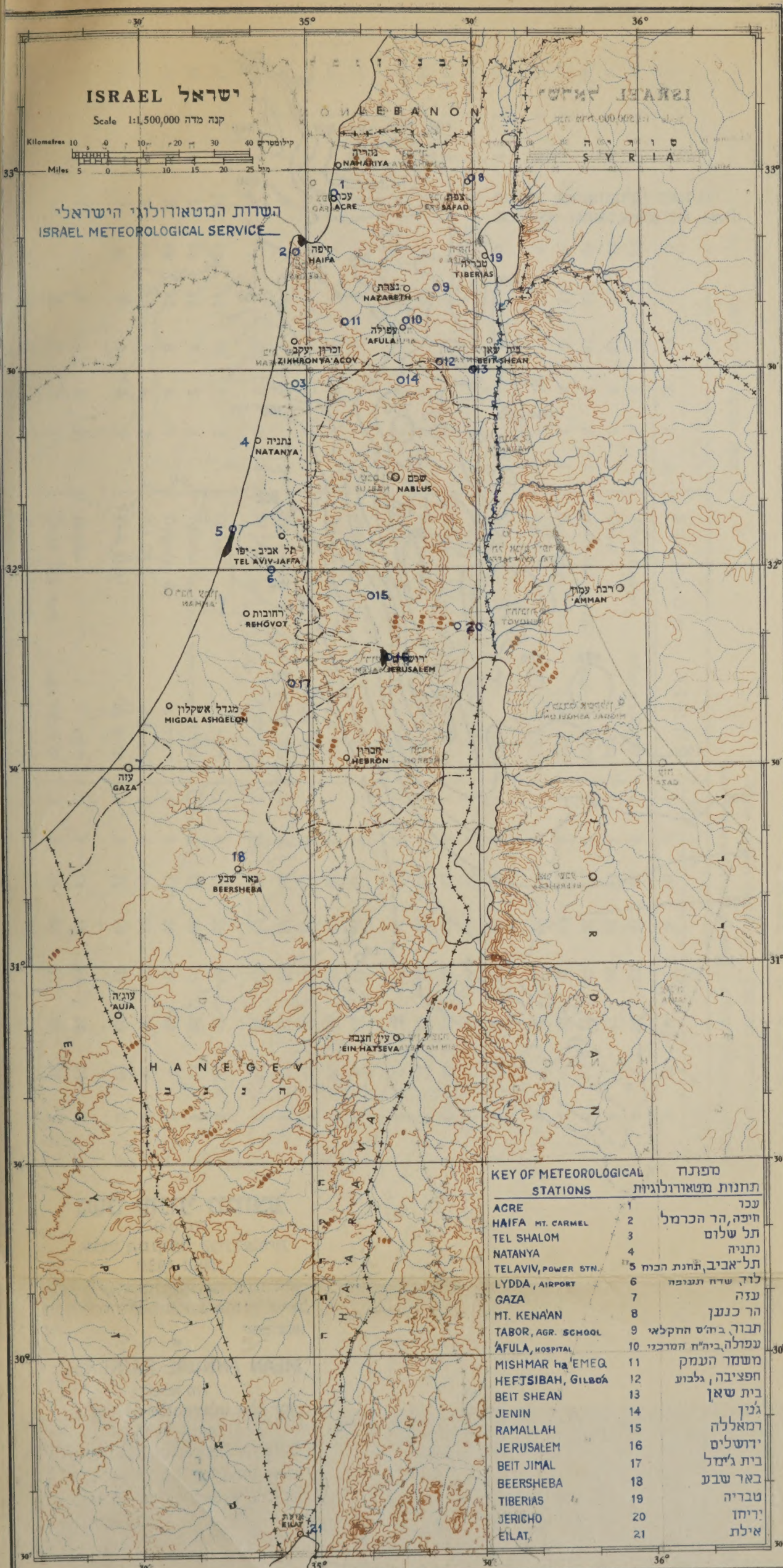
12.8	17.4	20.8	23.3	24.9	24.5	22.3	19.5	14.7	11.6	10.3	10.4	Tiberias	טבריה	19.9	26.5	31.7	34.8	36.6	36.5	35.0	32.6	26.5	21.1	18.9	17.8
11.6	15.9	19.8	22.5	24.0	23.6	21.9	19.6	14.8	11.4	10.1	9.8	Jericho	יריחו	21.8	28.4	33.8	36.7	38.5	38.8	37.4	34.8	29.3	23.8	21.4	20.1
11.4	16.2	20.3	24.4	25.6	25.4	23.2	21.8	17.5	13.0	10.0	9.7	Eilat	אילת	23.4	28.7	32.8	37.4	40.3	39.6	38.2	35.3	31.1	26.0	22.3	20.9

ISRAEL יִשְׂרָאֵל

Scale 1:1,500,000 קנה מדה



השירות המטאורולוגי הישראלי
ISRAEL METEOROLOGICAL SERVICE

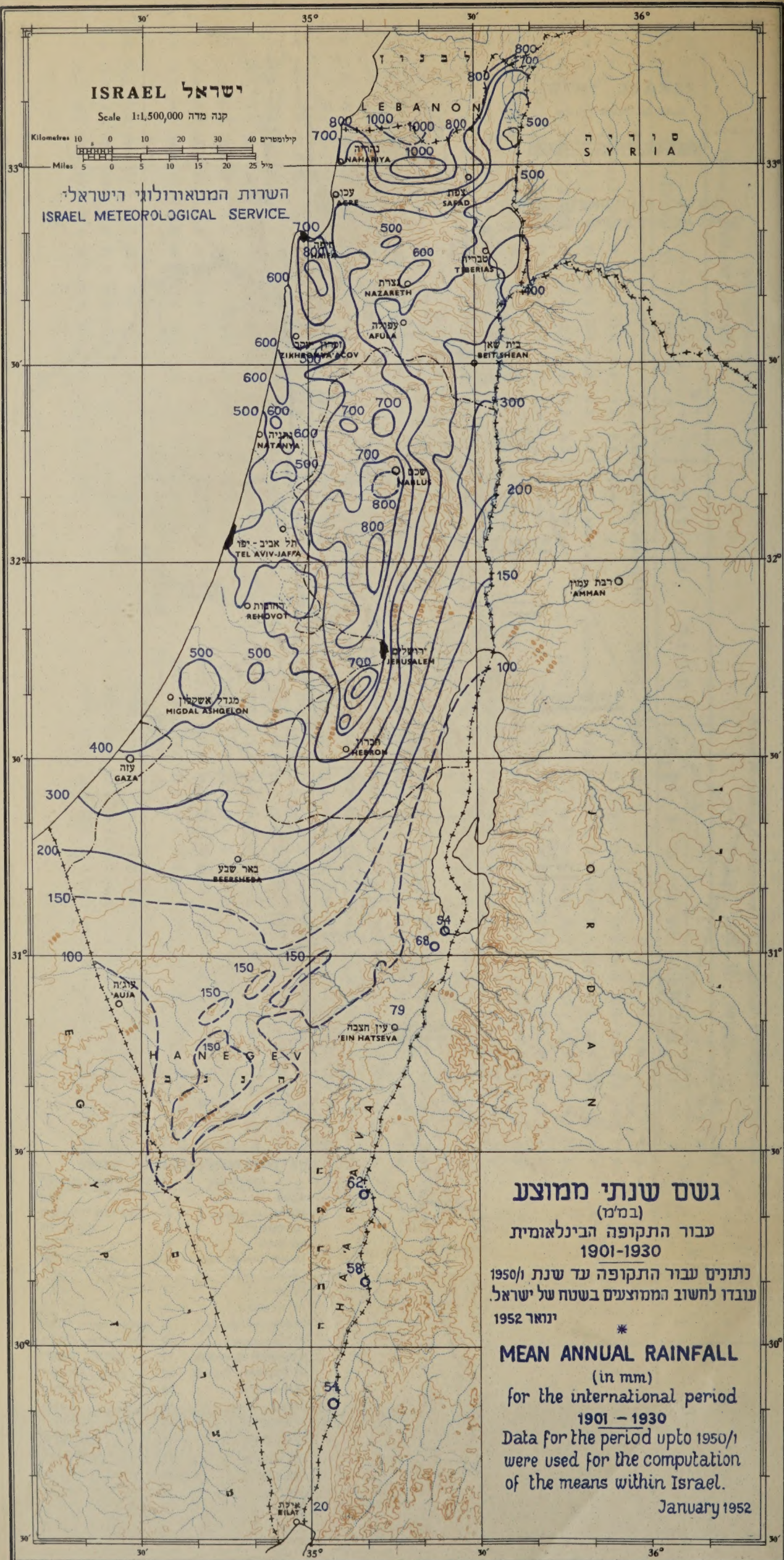


KEY OF METEOROLOGICAL STATIONS

מפתח תחנות מטאורולוגיות

ACRE	1
HAIFA, MT. CARMEL	2
TEL SHALOM	3
NATANYA	4
TEL AVIV, POWER STN.	5
LYDDA, AIRPORT	6
GAZA	7
MT. KENA'AN	8
TABOR, AGR. SCHOOL	9
AFULA, HOSPITAL	10
MISHMAR Ha'EMEQ	11
HEFTSIBAH, Gilboa	12
BEIT SHEAN	13
JENIN	14
RAMALLAH	15
JERUSALEM	16
BEIT JIMAL	17
BEERSHEBA	18
TIBERIAS	19
JERICHO	20
EILAT	21

עכו	1
חיפה, הר הכרמל	2
תל שלום	3
נתניה	4
תל-אביב, תחנת הכוח	5
לוד, שדה תעופה	6
עזה	7
הר כנען	8
תבור, ביה"ס החקלאי	9
עפולה, ביה"ח המרכזי	10
משמר העמק	11
חפציבה, גלבוע	12
בית שאן	13
ג'נין	14
רמאללה	15
ירושלים	16
בית ג'מל	17
באר שבע	18
טבריה	19
יריחו	20
אילת	21



ישראל ISRAEL

קנה מדה 1:1,500,000 Scale

קילומטרים 0 10 20 30 40
Miles 0 5 10 15 20 25

השרות המטאורולוגי הישראלי
ISRAEL METEOROLOGICAL SERVICE

גשם שנתי ממוצע

(במ"מ)

עבור התקופה הבינלאומית
1901-1930

נתונים עבור התקופה עד שנת 1950/1
עובדו לחשוב הממוצעים בשטח של ישראל.

ינואר 1952

MEAN ANNUAL RAINFALL

(in mm)

for the international period
1901 - 1930

Data for the period upto 1950/1
were used for the computation
of the means within Israel.

January 1952

ט ב ל ה III TABLE

Mean number of rainy days מספר ממוצע של ימי גשם

Cont.

המשך

ט ב ל ה II TABLE

Mean monthly rainfall as כמות הגשם החדשית הממוצעת
percentage of the annual total באחוזים מן הכמות השנתית

חודש										STATION	ה ת ח נ ה	חודש									
Month	V	IV	III	II	I	XII	XI	X	IX			Month	V	IV	III	II	I	XII	XI	X	IX
שנה Year																					
58	2	4	10	10	13	11	6	2	.	'Afula, Hospital	עפולה, בית החולים	2	5	10	19	25	26	9	4	.	.
58	1	4	9	11	14	10	6	3	.	Geva'	גבע	1	5	10	20	26	23	9	6	.	.
58	2	4	9	11	13	10	6	2	1	Heftsi-bah, Gilboa'	חפציבה, גלבוע	1	4	11	20	28	21	10	5	.	.
49	1	3	8	9	12	8	5	2	1	Beit Shean	בית שאן	1	5	10	19	27	23	9	6	.	.
49	1	3	8	9	12	9	5	2	.	Jenin	ג'נין	1	6	9	21	28	22	9	4	.	.
47	1	3	6	9	12	8	6	2	.	Nablus	שכם	1	7	10	22	25	24	9	2	.	.
54	1	4	11	9	11	10	6	2	.	Ma'ale ha Hamisha	מעלה החמישה	1	6	12	21	24	22	11	3	.	.
52	2	3	8	9	12	9	7	2	.	Jerusalem Palace Hotel	ירושלים, מלון פלס	1	6	12	22	26	21	10	2	.	.
54	1	4	11	9	10	9	7	3	.	Beit Jimal	בית ג'ימל	1	6	11	21	24	22	12	3	.	.
52	2	4	9	9	11	9	6	2	.	Hebron	חברון	1	7	12	22	26	21	9	2	.	.
36	1	1	6	7	8	7	5	1	.	Dhahiriya	דהריה	.	7	16	19	25	23	9	1	.	.
20	1	.	3	3	6	4	3	.	.	Urim, El 'Imara	אורים, אל עמרה	.	2	10	17	25	23	20	3	.	.
28	1	2	5	6	6	4	3	1	.	Beersheba	באר שבע	.	6	14	18	23	25	12	2	.	.
18	1	1	4	3	4	3	2	.	.	Bir 'Asluj	ביר עסלוג'	3	8	20	14	22	21	11	1	.	.
13	.	1	2	2	3	2	2	1	.	El 'Auja	אל עוג'ה	2	11	18	18	20	15	13	3	.	.
64	3	6	10	12	14	10	7	2	.	Dafna	דפנה	2	7	11	20	27	21	9	3	.	.
45	1	3	5	10	12	8	5	1	.	Tiberias Forestry Stn.	טבריה, משתלות היעור	2	5	11	20	25	22	11	4	.	.
52	1	4	9	10	13	8	6	1	.	Deganya A	דגניה א'	1	7	12	20	27	20	9	4	.	.
51	1	3	8	10	12	9	6	2	.	Tel Or	תל אור	1	6	11	20	27	20	9	6	.	.
43	.	3	7	8	9	9	5	2	.	Tirat Tsevi	טירת צבי	3	5	11	19	23	23	10	6	.	.
32	1	2	5	6	7	6	4	1	.	Jericho	יריחו	2	7	11	18	23	24	13	2	.	.
20	1	1	3	4	5	3	2	1	.	Dead Sea, North	ים המלח, צפון	2	7	11	16	22	24	14	4	.	.
15	1	1	2	3	3	2	2	1	.	Dead Sea, South	ים המלח, סדרם	4	8	16	14	23	21	5	9	.	.
7	.	1	2	1	1	1	1	.	.	Eilat	אילת	6	11	24	13	6	28	11	1	.	.

TABLE III ט ב ל ה

Mean number of rainy days מספר ממוצע של ימי גשם

Month	חודש								
שנה Year	V	IV	III	II	I	XII	XI	X	IX
69	2	4	10	12	16	13	8	3	1
61	2	4	8	10	14	12	8	3	.
67	1	5	9	12	15	12	8	4	1
64	2	5	11	11	14	11	7	3	.
65	2	4	10	11	14	13	7	3	1
67	2	5	11	11	14	12	7	4	1
56	1	3	8	10	13	11	7	3	.
56	1	3	7	10	13	11	7	3	1
63	1	4	8	12	14	12	8	3	1
60	2	4	11	10	12	11	7	3	.
54	2	3	8	10	11	10	7	3	.
43	1	3	6	8	9	9	6	1	.
45	1	3	8	8	10	9	5	1	.
41	1	2	6	8	9	8	5	2	.
66	2	6	9	13	15	12	7	2	.
79	3	7	14	14	16	13	8	4	.
61	2	4	9	11	14	12	6	3	.
56	1	4	8	12	13	10	6	2	.
60	2	4	10	11	14	10	7	2	.
58	1	4	9	9	14	11	7	3	.

TABLE II ט ב ל ה

Mean monthly rainfall as כמות הגשם החדשית הממוצעת
percentage of the annual total באחוזים מן הכמות השנתית

Month	חודש								
שנה Year	V	IV	III	II	I	XII	XI	X	IX
Nahariya נהריה	1	4	6	15	27	25	16	5	1
Qiryat Haiyim קרית חיים	1	5	6	17	30	26	12	3	.
Haifa, Tech. College חיפה, הטכניון העברי	1	5	6	15	27	28	13	4	1
'Ein ha Shofet עין השופט	1	3	9	20	27	24	10	6	.
Tel Shalom תל שלום	1	4	7	18	27	26	11	5	1
'Ein ha Horesh עין החורש	1	7	8	19	24	26	10	5	.
Natanya נתניה	.	6	8	16	28	25	13	4	.
Herzliya הרצליה	.	3	8	19	30	24	12	4	.
Tel Aviv, Nahmani st. תל אביב, רח' נחמני	.	3	8	17	28	26	13	4	1
Lydda, Airport לוד, שדה התעופה	1	4	9	21	28	21	12	4	.
Rehovot, Exp. Stn. רחובות, תח. לחקר חקל	.	4	10	19	31	22	11	3	.
'Eqron עקרין	1	4	10	19	32	19	12	3	.
Beer Tuviya באר טוביה	.	3	10	19	27	25	13	3	.
Gaza עזה	.	4	10	17	25	26	14	4	.
Kefar Gil'adi כפר גלעדי	2	8	12	22	26	18	8	4	.
Mt. Kena'an הר כנען	3	6	12	21	25	21	9	3	.
Faradiya פרדיה	1	7	11	21	29	19	8	4	.
Nazareth, Forest. Stn. נצרת, משתלות היעור	1	5	10	20	27	23	10	4	.
Tabor, Agr. School תבור, בי"ס חקלאי	1	5	10	22	27	23	9	3	.
Ramat David רמת דוד	1	4	9	20	25	25	11	5	.

Month חודש	Year שנה												Station מחנה	Height (m) גובה (מ')	Lat. °N. רוחב	Long. °E. אורך	Name שם
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII					

C. THE RIFT VALLEY ג. שקע הירדן

1. LAKE HULA AREA אזור החולה

582	12.7	42.8	61.4	115.5	159.9	120.4	51.4	17.9	.
446	10.0	26.0	44.0	99.6	114.2	95.8	40.6	9.0	0.8
495	8.1	26.8	51.8	102.4	137.3	103.0	53.3	11.6	0.7
547	11.7	30.8	56.5	130.9	142.1	122.4	51.9	11.2	.

2. CENTRAL JORDAN VALLEY עמק הירדן המרכזי

545	0.8	15.9	55.3	105.7	180.5	104.7	63.2	18.1	0.8
456	9.5	23.1	47.8	90.8	116.3	101.2	47.7	19.6	.
393	8.3	30.5	46.1	75.3	111.6	79.3	35.2	11.7	.
873	3.3	24.2	39.7	78.2	100.2	78.1	34.5	14.6	0.2
829	2.6	21.2	39.2	67.5	87.5	71.6	30.8	8.5	0.1

889	8.3	22.9	42.6	82.9	102.9	83.7	36.4	14.0	0.3
874	3.0	20.1	40.0	81.0	101.5	76.2	33.8	18.8	0.1
415	5.1	23.6	47.4	83.6	111.4	83.0	36.0	24.8	0.1
293	8.1	15.4	31.5	55.4	67.1	67.4	29.9	18.2	.

3. DEAD SEA AREA אזור ים המלח

133	2.6	8.9	14.6	24.9	30.0	31.3	19.1	1.6	.
162	3.3	11.5	17.6	29.8	37.9	38.1	20.1	3.7	.
99	1.4	7.3	11.4	15.4	20.7	24.4	14.3	4.1	.
54	2.3	4.1	8.8	7.2	12.5	11.5	2.7	4.9	.

4. WADI 'ARABA אילת *

22	1.5	0.7	6.0	3.2	1.8	7.1	1.8	0.4	.
----	-----	-----	-----	-----	-----	-----	-----	-----	---

* ערכי הגשם באילת אינם מתיחסים לתקופה הסטנדרטית 1901—1930; הם התקבלו כממוצעים אריתמטיים של הנתונים שנמדדו רק בעונות הגשמים 1940/41; 1942/43; 1946/47; 1949/50—1950/51.

* Rainfall data of Eilat do not refer to the standard period 1901—1930, but constitute arithmetical means of the rainfall years on record, i. e. 1940/41; 1942/43—1946/47; 1949/50—1950/51.

חודש										STATION	גובה (מ') Height (m)	רוחב Lat. ° N.	אורך Long. ° E.	ה ת ח נ ה
שנה Year	V	IV	III	II	I	XII	XI	X	IX					
295	0.8	16.0	38.7	71.6	85.4	54.9	24.7	2.9	.	'Ein Fara	310	31 50	35 18	עין פארה
543	1.9	25.5	53.3	102.2	132.0	141.1	69.4	17.6	.	Hulda	125	31 50	34 53	חולדה
674	4.6	42.7	81.3	141.9	163.9	145.3	74.3	20.0	.	Ma'ale ha Hamisha	810	31 49	35 08	מעלה החמישה
555	4.5	23.4	66.3	117.8	152.6	116.4	59.0	15.0	.	Bab el Wad	350	31 49	35 01	שער הגיא
738	4.7	46.5	90.9	155.1	188.2	154.1	80.0	18.3	0.2	Qiryat Anavim	700	31 48	35 07	קרית ענבים
714	4.0	40.5	85.2	142.5	186.6	155.4	83.0	16.8	.	Saris	600	31 48	35 04	סריס
743	3.2	50.7	90.8	161.5	186.9	153.2	80.2	16.5	.	Motsa, Arza	720	31 48	35 10	מוצא, ארזה
243	1.0	12.0	25.4	48.1	59.8	75.4	19.5	1.8	.	Khan el Ahmar	280	31 49	35 22	חן אל אחמר
592	3.4	36.3	74.1	136.6	156.9	116.9	57.0	8.5	2.3	Jerusalem, Heb. Uni.	825	31 48	35 15	ירושלים, האוני. העב.
622	3.0	34.4	75.4	142.8	162.9	123.9	68.4	11.1	0.1	Jerusalem, Romema	830	31 47	35 12	ירושלים, רוממה
598	4.4	38.3	72.9	142.1	148.6	124.5	57.6	9.5	0.1	Jerusalem, Amer. Col.	750	31 48	35 14	ירושלים, מוש. אמר.
614	4.2	39.6	76.2	137.0	156.1	125.9	64.2	10.7	0.1	Jerusalem, Engl. Hos.	810	31 47	35 13	ירושלים, בי"ח אנגלי
571	3.2	34.9	71.0	133.9	145.8	116.8	55.8	9.5	0.1	Jerusalem, St. Anne.	740	31 47	35 14	ירושלים, סט. אן
571	2.8	35.9	71.0	128.3	149.8	116.9	57.0	9.2	0.1	Jerusalem, N.D. de F.	800	31 47	35 13	ירושלים, נוטר דם
573	3.3	37.3	70.3	125.9	149.5	117.9	58.1	10.7	.	Jerusalem, Pal. Hot.	785	31 47	35 13	ירושלים, מלון פלס
663	4.5	42.6	82.2	147.2	169.9	133.8	70.9	11.7	0.2	Jerus'm, Beit ha Ker.	800	31 47	35 11	ירושלים, בית הכרם
524	1.9	29.3	58.0	102.8	129.2	114.9	73.6	14.3	.	Deir Rafat	250	31 46	34 57	דיר רפאת
519	2.8	31.2	61.5	109.6	132.5	104.5	65.4	11.5	.	Hartuv	240	31 46	35 00	הרטוב
551	2.3	33.0	60.7	114.3	133.4	123.3	67.6	16.4	.	Beit Jimal	360	31 43	34 59	בית ג'ימל
613	6.0	46.3	76.3	137.9	164.2	119.9	52.9	9.5	.	Bethlehem	760	31 42	35 12	בית לחם
218	3.3	6.8	26.2	48.7	61.6	48.0	19.2	4.2	.	Mar Saba	250	31 42	35 20	מר סבא
828	4.1	54.1	115.4	191.6	212.8	161.0	71.2	17.7	0.1	Solomon's Pools	775	31 41	35 10	ברכות שלמה
547	4.4	37.9	67.3	119.6	142.3	112.9	53.5	8.9	0.2	Hebron	930	31 32	35 04	חברון
390	2.4	26.0	61.8	72.6	96.3	90.0	36.2	4.7	.	Dhahiriya	660	31 24	34 58	דהריה
5. NEGEV הנגב														
242	1.0	5.2	23.1	41.9	60.9	55.0	48.5	6.4	.	Urim, El 'Imara	90	31 19	34 31	אורים, אל עמרה
227	2.4	13.2	31.3	40.6	52.0	56.1	26.4	5.0	.	Beersheba	270	31 14	34 47	באר שבע
114	3.0	9.3	22.8	16.5	24.9	23.7	12.4	1.4	.	Bir 'Asluj, Mashabim	320	31 01	34 46	ביר עסלוג, משאבים
87	2.2	9.9	15.9	15.1	17.4	12.7	11.2	2.6	.	El 'Auja	250	30 52	34 26	אל עוג'ה

חודש										STATION	גובה (מ') Height (m)	רוחב Lat. ° N.	אורך Long. ° E.	החנה
שנה Year	V	IV	III	II	I	XII	XI	X	IX					
2. PLAIN OF ESDRAELON														2. עמק יזרעאל
547	4.4	23.9	54.4	107.1	142.8	134.3	59.7	20.4	.	Nahalal	80	32 41	35 12	נהלל, ביי"ס חקלאי
582	5.6	18.4	48.8	114.7	149.6	162.0	65.9	16.8	0.2	Kefar Yehoshua	60	32 41	35 09	כפר יהושוע
520	6.6	20.9	47.7	101.5	128.6	131.9	57.2	25.4	0.2	Ramat David, Qevutsa	80	32 41	35 12	רמת דוד, הקבוצה
510	6.1	21.3	46.2	99.1	122.5	134.4	56.4	23.6	0.4	Gevat	110	32 41	35 13	גבת
508	4.5	24.2	48.7	96.4	131.2	123.0	53.3	26.6	0.1	Sarid	110	32 40	35 13	שריד
584	7.5	27.4	54.4	117.1	151.6	141.1	63.9	20.4	0.6	Gineigar	100	32 40	35 15	גניגר
506	5.6	21.6	50.9	96.4	139.9	112.8	59.8	18.9	0.1	Tel 'Adashim	110	32 39	35 18	תל עדשים
558	5.1	36.0	59.8	110.1	139.1	132.9	54.2	20.8	.	Mizra'	100	32 39	35 17	מזרע
614	4.6	19.4	52.4	131.2	162.1	151.5	68.2	24.6	.	Yoqne'am	75	32 39	35 07	יוקנעם
466	7.8	23.2	47.0	86.7	116.5	121.2	43.4	20.1	0.1	'Afula, Hospital	130	32 37	35 19	עפולה, ביה"ח המרכזי
467	8.4	23.4	48.3	91.6	116.8	113.7	49.1	20.0	0.7	'Afula, S W	65	32 36	35 17	עפולה, דרום מערב
476	6.3	24.1	44.8	92.3	130.0	112.3	45.3	20.6	0.3	Merhavva	60	32 36	35 18	מרחביה
618	5.6	20.5	52.5	127.8	178.2	143.7	58.5	31.1	0.1	Mishmar ha Emeq	100	32 37	35 08	משמק העמק
3. 'EIN HAROD—BEISAN PLAIN														3. מישור עין חרוד -- בית שאן
436	5.2	25.5	41.5	74.9	115.0	105.3	46.5	22.1	.	Kefar Yehesqel	30	32 34	35 22	כפר יחזקאל
466	4.6	22.9	45.1	92.3	120.2	107.3	43.9	29.5	0.2	Geva'	20	32 34	35 23	גבע
404	4.3	18.2	44.9	76.9	102.0	93.1	45.7	18.9	.	'Ein Harod	20	32 33	35 23	עין חרוד
409	4.7	17.4	49.2	77.0	106.0	92.5	43.3	18.9	.	Tel Yosef	5	32 33	35 24	תל יוסף
398	4.9	17.7	50.9	71.3	100.0	91.7	44.1	17.4	.	Beit ha Shita	-50	32 33	35 26	בית השיטה
426	4.0	19.2	45.3	84.7	121.4	90.1	41.5	19.5	0.3	Heftsi-bah	-110	32 31	35 26	חפציבה
347	3.6	17.9	41.1	66.0	94.8	73.2	34.3	15.9	0.2	Messilot	-120	32 30	35 28	מסילות
316	2.9	16.7	32.9	58.5	85.1	71.5	28.6	19.0	0.3	Beit Shean	-120	32 30	35 30	בית שאן
4. SAMARIAN AND JUDEAN HILLS														4. הרי שומרון ויהודה
490	4.4	28.6	46.7	101.7	136.4	106.8	44.6	20.6	0.2	Jenin	140	32 28	35 18	ג'נין
736	5.2	50.6	73.3	160.2	183.7	177.2	63.4	17.4	.	Nablus	490	32 13	35 18	שכם
800	3.4	60.7	97.0	181.6	200.8	182.5	61.3	12.6	0.1	Bir Zeit	780	31 58	35 12	ביר זית
670	4.2	49.0	75.8	142.7	176.5	145.3	64.0	12.5	.	'Atarot	740	31 52	35 13	עטרות
518	3.6	28.0	57.7	101.9	142.6	109.9	58.5	65.1	0.2	Latrun	200	31 50	34 59	לטרון

חודש										STATION	גובה (מ') Height (m)	רוחב Lat. ° 'N.	אורך Long. ° 'E.	ה ת ח נ ה
שנה Year	V	IV	III	II	I	XII	XI	X	IX					
492	1.7	18.6	53.3	95.3	145.3	105.9	55.7	15.3	0.9	Rehovot, town	50	31 53	34 49	רחובית, עיר
491	2.2	20.0	51.6	102.5	149.2	99.1	58.3	7.8	0.3	Na'an	75	31 53	34 51	נען
469	2.4	16.8	48.4	89.6	147.3	90.0	57.7	15.2	1.6	'Eqron	60	31 51	34 50	עקרון
473	2.2	17.8	44.6	98.5	126.3	115.0	59.7	13.7	0.2	Gedera	55	31 49	34 46	גדרה
4. מישור החוף הדרומי SOUTHERN COASTAL PLAIN														
419	2.2	14.8	38.4	81.7	121.1	95.4	51.9	13.5	.	Masniya el Kabira	60	31 34	34 47	מסמיה
489	1.4	15.8	50.0	92.8	130.3	119.9	64.4	14.0	0.4	Beer Tuviya	55	31 44	34 44	באר טוביה
484	3.1	16.4	47.4	99.6	130.2	113.0	59.2	15.1	.	Kefar Menahem	125	31 44	34 50	כפר מנחם
423	0.7	9.5	36.7	71.6	118.0	108.4	63.0	15.0	0.1	Migdal Ashqelon	40	31 40	34 35	מגדל אשקלון
422	1.7	14.2	36.6	83.8	118.4	94.4	54.2	18.4	0.3	Majdal, Agr. Stn.	50	31 40	34 36	מגדל התחנה החקלאית
398	1.3	16.2	40.5	75.1	110.1	93.6	49.1	11.6	0.5	Faluja	100	31 38	34 45	פלוג'ה
388	1.8	17.3	36.0	66.2	94.6	99.0	56.2	16.7	0.2	Gaza	45	31 31	34 27	עזה
272	1.7	17.0	21.8	47.2	63.1	63.9	46.9	10.3	0.1	Khan Yunis	45	31 21	34 19	חן יונס
B. HILL REGION ב. איזור ההרים														
1. HILLS OF GALILEE 1. הרי הגליל														
861	18.5	60.3	106.7	184.2	237.6	151.8	61.5	40.2	0.2	Metulla, Police Post	500	33 17	35 35	מטולה, תח. המשטרה
894	21.3	70.0	96.3	175.6	240.5	173.6	80.8	34.4	1.5	Metulla, Colony	520	33 17	35 35	מטולה, מושבה
814	16.1	61.5	94.5	176.5	216.3	148.9	68.9	31.1	0.2	Kefar Gil'adi	340	33 15	35 34	כפר גלעדי
866	12.0	74.0	61.5	161.9	258.5	177.2	94.8	26.1	.	Miilya	500	33 01	35 16	מעיליה
740	19.9	44.2	87.8	157.9	186.9	153.7	67.8	21.6	0.2	Mt. Kena'an	934	32 59	35 30	הר כנען
762	10.9	51.1	80.0	169.5	199.8	139.9	87.0	23.7	0.1	Rosh Pina	450	32 53	35 32	ראש פנה
790	10.4	54.4	85.3	169.2	226.4	152.0	62.3	29.2	0.8	Faradiya	425	32 56	35 25	פרדיה
495	13.6	23.6	49.1	102.1	129.1	104.5	49.5	23.4	0.1	Mitspa	175	32 47	35 30	מצפה
522	5.9	23.7	54.6	112.5	137.6	111.7	50.2	25.7	0.1	Sejera	270	32 45	35 24	סג'רה
620	4.7	30.1	52.7	126.6	177.0	145.2	67.4	16.2	0.1	Neve Ya'ar	175	32 44	35 10	נוה יער
609	5.1	25.1	50.2	128.4	165.9	151.8	60.8	21.7	.	Sha'ar ha 'Amaqim	60	32 43	35 07	שער העמקים
466	4.0	23.3	49.0	104.9	127.2	103.7	39.9	13.9	0.1	Yavneel	-80	32 42	35 30	יבנאל
656	7.3	33.8	70.5	136.0	173.5	152.7	62.1	19.6	0.5	Nazareth For. Stn.	440	32 42	35 18	נצרת, משתלות היעור
563	5.7	25.7	55.9	115.2	145.7	130.1	56.5	27.7	0.5	Kefar ha Horesh	430	32 42	35 16	כפר החורש
494	4.4	26.6	53.5	106.6	131.7	112.7	44.5	14.0	.	Tabor, Agr. Sch.	144	32 42	35 24	תבור, בייס החקלאי
497	4.8	24.3	53.3	107.1	132.3	112.9	46.8	15.4	0.1	Kefar Tabor	130	32 41	35 25	כפר תבור

חודש										STATION	גובה (מ') Height (m)	רוחב Lat. ° N.	אורך Long. ° E.	ה ת ח נ ה
Month	V	IV	III	II	I	XII	XI	X	IX					
שנה Year														
618	11.8	23.7	33.2	36.8	154.7	202.9	88.6	20.4	1.9	Hadera	20	32 26	34 55	חדרה
634	5.6	42.6	53.2	120.1	149.2	166.8	62.0	34.3	0.7	'Ein ha Horesh	30	32 23	34 56	עין החורש
556	3.2	26.6	43.7	89.0	134.1	152.4	72.9	34.1	.	Kefar Vitkin	20	32 23	34 52	כפר ויתקין
545	3.8	25.1	44.7	92.3	122.5	156.6	69.9	30.4	0.2	Ma'abarot	20	32 22	34 54	מעברות
466	0.8	27.6	37.2	77.1	128.2	116.4	61.8	16.9	.	Natanya	35	32 20	34 51	נתניה
564	4.7	24.1	43.8	112.0	159.8	142.1	57.4	20.4	0.2	Tulkarem	80	32 19	35 01	טול כרם
525	3.0	13.7	37.7	96.8	166.0	117.8	68.5	21.4	0.6	Tel Mond	70	32 15	34 55	תל מונד
516	2.5	17.4	41.9	101.4	161.4	109.3	61.6	19.7	0.8	Qalmaniya	70	32 12	34 55	קלמניה
472	0.9	16.3	37.7	93.3	132.7	109.4	59.7	21.2	0.8	Rishpon	20	32 12	34 49	רשפון
533	2.1	13.7	48.9	108.2	170.9	112.0	64.1	17.7	0.4	Kefar Sava	40	32 11	34 54	כפר סבא. ב"ס עממי
558	2.0	16.1	45.8	103.9	169.3	131.8	64.9	23.2	1.5	Herzliya	50	32 10	34 50	הרצליה
518	1.5	16.3	46.3	95.2	161.3	114.3	63.1	19.4	0.6	Hadar ha Sharon	40	32 09	34 53	הדר השרון
473	2.5	16.7	43.3	86.0	134.1	113.2	56.9	20.3	.	Ramat ha Sharon	70	32 09	34 50	רמת השרון
476	2.4	14.5	39.2	79.9	126.5	122.7	69.2	21.6	.	Tel-Aviv, Pow.Stn.	3	32 06	34 47	תל-אביב, תחנת כוח
543	2.8	17.8	53.8	104.7	161.7	119.2	62.0	19.5	1.5	Petah Tiqva	50	32 05	34 53	פתח תקוה
493	1.5	15.7	40.6	80.7	139.2	125.0	68.4	20.1	1.8	Tel Aviv, North	10	32 05	34 46	תל-אביב, צפון
515	2.1	15.8	41.1	91.9	144.0	133.6	65.9	18.8	1.8	Haqiriya, Sarona	25	32 04	34 47	הקריה, שרונה
540	1.9	15.6	43.8	92.3	152.2	139.2	70.6	22.5	1.9	Tel Aviv, Nach. St.	20	32 04	34 46	תל-אביב, רח' נחמני
513	1.3	15.6	48.0	81.3	141.0	148.3	63.3	12.4	1.8	Jaffa	20	32 03	34 45	יפו
524	1.9	15.8	42.0	92.6	146.8	134.3	64.3	22.9	3.4	Miqve Yisrael	20	32 02	34 47	מקוה ישראל
508	2.9	21.1	47.4	96.9	148.0	109.9	58.6	20.5	2.7	Wilhelma	50	32 01	34 55	וילהלמה
505	2.1	22.5	47.4	105.9	142.2	102.9	59.7	21.0	1.3	Lydda Airport	40	32 00	34 54	לוד, שדה תעופה
532	2.6	16.8	48.1	108.6	159.3	115.8	60.4	19.3	1.1	Gan Moshe	50	31 59	34 49	גן משה
484	5.0	17.1	50.6	103.9	128.8	111.2	54.1	6.9	1.4	Sarafand	50	31 58	34 51	צריפין
480	1.3	18.4	49.8	98.6	139.3	104.0	46.9	19.8	1.4	Ben Shemen	100	31 58	34 56	בן שמן
518	1.4	14.7	43.5	102.5	154.6	120.0	60.6	19.0	1.7	Rishon le Zion	60	31 57	34 48	ראשון לציון
516	1.9	21.7	44.3	96.8	150.8	121.6	61.1	16.2	1.6	Nes Tsiona	25	31 55	34 48	נס ציונה
501	1.5	18.0	47.6	93.0	156.2	116.8	53.5	13.2	1.2	Netser, Bir Salim	75	31 55	34 50	נצר, ביר שלים
468	1.8	18.8	50.5	90.1	140.3	96.2	49.9	19.5	0.9	Ramle, School	65	31 56	34 52	רמלה, בית הספר
495	2.5	18.3	51.4	98.9	152.3	106.4	54.5	14.4	1.3	Rehovot, Exp. Stn.	65	31 54	34 49	רחובות תח' לחקר חקל

טבלה I TABLE

Mean monthly and annual rainfall (mm)
(reduced to period 1901 - 1930)

כמות הגשם החדשית והשנתית הממוצעת (מ"מ)
(מיוחס לתקופה 1901 - 1930)

חודש										STATION	גובה (מ') Height (m)	רוחב Lat. ° N.	אורך Long. ° E.	התחנה
שנה Year	V	IV	III	II	I	XII	XI	X	IX					
A. COASTAL REGION														
1. HAIFA-ACRE PLAIN														
746	12.6	50.6	46.7	112.9	214.9	165.3	111.0	25.5	6.5	Rosh ha Niqra	60	33 05	35 06	ראש הנקרה
711	7.0	30.0	48.2	104.5	194.7	174.9	116.7	36.6	8.4	Nahariya	5	33 00	35 05	נהריה
652	7.3	33.3	41.4	114.4	175.7	161.8	86.1	29.4	2.6	Acre	10	32 56	35 06	עכו
616	8.8	29.4	36.4	104.4	183.1	160.3	73.3	18.9	1.4	Qiryat Haiyim	10	32 49	35 04	קריית חיים
710	12.3	35.4	38.4	119.3	216.8	177.2	85.8	24.8	.	Haifa, Airport	5	32 49	35 02	חיפה, שדה תעופה
544	5.6	20.8	47.2	107.8	146.4	117.4	67.4	30.8	0.6	Ramat Yohanan	55	32 47	35 07	רמת יוחנן
2. CARMEL RANGE														
665	5.9	25.8	40.1	110.3	176.6	185.1	93.9	25.1	2.2	Haifa, Town	10	32 49	34 59	חיפה, עיר
750	9.5	31.9	47.1	116.0	201.6	214.1	99.6	26.4	3.8	Haifa, Tech. College	85	32 49	35 00	חיפה, הטכניון העברי
739	9.3	31.3	46.3	114.0	199.6	211.1	97.9	25.9	3.6	Haifa, Mt. Carmel	300	32 48	34 59	חיפה, הר הכרמל
728	9.3	32.6	47.6	134.7	215.3	175.1	83.5	29.0	0.9	Nesher	10	32 46	35 03	נשר
848	10.9	35.5	57.0	158.2	243.0	212.8	105.3	25.0	0.3	Yagur	30	32 45	35 05	יגור
550	6.0	22.7	25.3	78.0	135.6	165.0	91.8	24.3	1.3	'Atlit, Salt Company	10	32 41	34 56	עתלית, חברת המלח
676	5.9	24.6	40.7	108.2	162.3	210.1	99.6	24.6	.	'Atlit, Village	90	32 41	34 57	עתלית, מושבה
633	7.6	22.3	55.2	126.9	172.9	150.7	60.9	36.4	0.1	'Ein ha Shofet	270	32 36	35 06	עין השופט
662	6.6	35.2	38.3	99.1	177.2	196.4	86.1	22.1	1.0	Meir Shefeiya	100	32 35	34 58	מאיר שפיה
674	7.3	35.7	39.9	107.2	174.3	194.6	92.5	21.6	0.9	Zikhron Ya'akov	150	32 34	34 57	זכרון יעקב
3. CENTRAL COASTAL PLAIN														
621	8.2	26.4	44.4	113.4	166.7	160.5	69.8	29.2	2.4	Tel Shalom	70	32 28	34 59	תל שלום
612	6.6	34.5	41.1	99.6	148.1	197.6	61.8	16.1	6.6	Caesarea	10	32 30	34 53	קיסריה
597	7.9	30.0	45.1	103.1	162.4	155.0	68.1	25.0	0.4	'Ein Shemer	40	32 28	35 01	עין שמר, הקבוץ
591	6.3	30.8	46.7	103.8	159.3	152.6	66.6	24.5	0.4	Gan ha Shomron	25	32 28	35 00	גן השומרון, חב' המים
582	6.8	13.1	45.2	94.7	154.4	153.5	73.9	40.5	0.4	Gan Shemuel	30	32 27	34 57	גן שמואל

הגשמים. עודף או גרעון בכמות הגשם של חודש מסויים עשוי לגרום לסטיות ניכרות של אלמנטים מטאורולוגיים אחרים. דוגמא: הטמפרטורות הממוצעות לחדשי מרס בעשור 49 — 1940 נראות נמוכות מדי ב- 0.5°C — 1.5°C הן בהשוואה עם ממוצעי מרס בשנים קודמות והן בהשוואה עם ממוצעי פברואר ואפריל של אותו עשור. נראה שיש לזקף זאת על חשבון העובדה שגשמי מרס בעשור שנים זה היו מרובים במיוחד, ובירושלים עלו על כל הכמויות שירדו בעשורים האחרים בתקופה 1900—1949 (ראה טבלה ב'). בקשר לכך נראה גם שממוצעי הלחות היחסית והעננות לחודש מרס בעשור 49—1940 הגם גבוהים מהערכים שהיו מתקבלים מסדרת שנים ארוכה יותר.

ט ב ל ה ב': כמות הגשם הממוצעת (מ"מ) בחודש מרס בירושלים (העיר העתיקה)

התקופה	1900 — 09	1910 — 19	1920 — 29	1930 — 39	1940 — 49
מ"מ	64.0	99.6	40.4	46.1	106.5

לגבי כמויות גשם שנתיות, ועל אחת כמה וכמה לגבי כמויות חדשיות, עשר שנים הן תקופה קצרה מדי לחישוב ממוצעים רב שנתיים. הכמות השנתית הממוצעת בעיר העתיקה בירושלים, למשל, השתנתה מ-649 מ"מ בעשור 1877—1886 ל-419 מ"מ בעשור 1924—1933. לפיכך נודעת חשיבות לעובדה שלצורך חישוב ממוצעי הגשם עמדו לרשותנו כמה תחנות בהן נערכו תצפיות גשם רצופות בתקופה 1901—1930. נתוני תחנות אחרות שספקן מדידות לפחות במשך 10 שנים, ואשר ערכן בעת ובעונה אחת עם המדידות של התחנות הותיקות, חושבו ותוקנו על סמך השוואה עם נתוני תחנות ותיקות אלו לפי העיקרון של "קביעות היחס" בין כמויות הגשם בתחנות דומות.

אשר לחישוב הממוצע היומי של אלמנטים אקלימיים שונים, נסינו למצוא נוסחה מוסכמת אשר הממוצע המחושב לפיה יתקרב ככל האפשר אל הממוצע היומי האמיתי (ז. א. זה המתקבל מ-24 מדידות ביממה).

לצורך חישוב הטמפרטורה היומית הממוצעת נמצא שהנוסחה $2 / (\text{מקסימום} + \text{מינימום})$ נותנת ערכים הסוטים מהממוצעים האמיתיים פחות מאשר הערכים המתקבלים מנוסחה הכוללת את הטמפרטורות בשלש שעות התצפית 08, 14 ו-20 (זמן מקומי תקין). לפיכך חושבו כל ממוצעי הטמפרטורה לפי הנוסחה $2 / (\text{מקס.} + \text{מינ.})$. לגבי יתר האלמנטים נמצא שהממוצע האריתמטי של ערכי התצפיות בשעות הנהוגות $3 / (08h + 14h + 20h)$ מתקרב אל הממוצע האמיתי במידה המניחה את הדעת: יש לציין אמנם שלגבי הלחות היחסית נמצאו נוסחות אחרות וטובות יותר, לפי האיזור אשר את ממוצעיו יש לחשב: בעמק הירדן, בין ים כינרת וים המלח, נתנה הנוסחה לחישוב הלחות היחסית הממוצעת $2 / (08h + 20h)$ קירוב טוב יותר מאשר הנוסחות האחרות, ואילו לגבי שדה התעופה בלוד התברר שהנוסחה $4 / (08h + 14h + 2 \times 20h)$ טובה יותר. ברם, מכיון שנראה שבמרבית התחנות נותנת הנוסחה $3 / (08h + 14h + 20h)$ את הקירוב הטוב ביותר לממוצעים האמיתיים של כמה אלמנטים ועל מנת להבטיח אחידות בשיטות החישוב, נתקבלה נוסחה זו לצורך חישוב ממוצעים יומיים של לחות יחסית ושל עננות בכל התחנות. עם זאת, אנו מקיום שנוכל במרוצת הזמן להגיש את פרוט החישובים הדרושים לכל האלמנטים בכל התחנות כדי לקבל מהממוצעים הנוכחיים את הממוצעים האמיתיים.

בעקב הענין המיוחד שיש באקלימה של אילת, החלטנו לצרף גם את הערכים הממוצעים של התחנה המטאורולוגית הקיימת שם, המסתמכים על תצפיות במשך 4—5 שנים מתוך התקופה 1945—1951 ועל מדידות גשם במשך זמן ממושך יותר. בעקב קוצר התקופה ובגלל העדר תחנה ותיקה מתאימה להשוואה, לא חושבו לגבי אילת ערכים נורמליים מקבילים לממוצעי התקופה 49 — 1940; הממוצעים הנוכחיים הגם שהם בלתי מתוקנים, מובאים בזה כדי לתת לקורא מושג-מה מתנאי האקלים השורר באילת.

* Conrad V. and Pollak L. W. (1950). Methods in Climatology. 2nd ed. Cambridge, Mass., Harvard University Press. p. 164.

מ ב ו א

הטבלאות המובאות בחוברת כוללות את הערכים הנורמליים הבאים (ממוצעי התקופה 30—1901) עבור תחנות גשם בארץ ישראל:

כמויות גשם חדשיות ועונתיות (150 תחנות); כמויות גשם חדשיות באחוזים מהכמות השנתית הנורמלית (44 תחנות); מספר ימי גשם בכל חודש ובעונה כולה (44 תחנות); וכן ערכים נורמליים ארעיים (לתקופה יותר קצרה) של טמפרטורה, לחות יחסית, עננות והתאדות ב־21 תחנות מטאורולוגיות. תצפיות מטאורולוגיות ממכשירים המוצבים בסוכות שונות וכן מדידות גשם נערכו בכמה תחנות בארצנו עוד במאה התשע עשרה. ברם, סוכות מטאורולוגיות תקינות בעלות תריס כפול הונהגו לראשונה רק בשנים 40—1938. משום כך שימש העשור 49—1940 כתקופה סטנדרטית לחישוב ממוצעים רב שנתיים של אלמנטים אקלימיים שונים פרט לגשם. אך בעקב מצב הבטחון בשלהי העשור, ובגלל סיבות שונות בשנים אחרות, לא היתה האפשרות בכל התחנות לערוך סדרות אחידות ורציפות של מדידות מטאורולוגיות אפילו לתקופה הזאת. במקרים כאלה הושלמו הנתונים על ידי השוואה עם תחנות מתאימות. השלמת נתוני הגשם נעשתה לאור העובדה שהיחס בין הכמויות הנמדדות באותו פרק זמן בתחנות דומות (מבחינה אקלימית) הוא כמעט קבוע. השלמת הנתונים של כל יתר האלמנטים נערכה לפי השיטה האומרת כי ההפרשים בין ערכי תחנות דומות, הנמדדים באותו פרק זמן, הם כמעט קבועים.* פרט לאילת, חושבו ממוצעי התקופה 49—1940 אך ורק מתחנות שסיפקו לפחות שש שנים של תצפיות שלמות והומוגניות. הארגון המטאורולוגי הבינלאומי (ורשה, 1935) החליט שכערכים נורמליים תקינים ייחשבו ממוצעי התקופה 30—1901. לפיכך יכולים לטעון שערכים נורמליים המופקים ממדידות במשך עשר שנים בלבד משמעותם לקויה ואין להוציא מהם מסקנות מהימנות. ברם, עקב הדרישה המרובה לערכים נורמליים מוקדמים עבור ארץ ישראל היה נראה הדבר לראוי להוציא לאור את הממוצעים הנוכחיים. כדי להעמיד את הקורא על ממדי התנודות העלולות לחול בערכים הממוצעים לתקופה של עשר שנים הוכנה טבלה א'.

ט ב ל ה א': השתנות הטמפרטורה הממוצעת ($^{\circ}\text{C}$) של תקופות בנות 10 שנים.

ה ת ק ו פ ה	ג ר י נ ו י ׳	ב י ר ו ת	מ ו ס ק ו ה
1901 — 30	9.9	21.1	3.7 (25 שנה בלבד)
1901 — 10	9.8	20.95	3.6
1911 — 20	9.9	20.9	3.6 (5 שנים בלבד)
1921 — 30	10.1	21.5	3.9
1931 — 40	10.2	21.6	4.7
(א) סכום הסטיות של ממוצעי			
העשור מן הממוצע 1901 — 30	0.6	1.25	1.4
(ב) התחום המוחלט של הסטיות	0.4	0.7	1.0

Clayton, H. H. 1927, 1934, 1947. World Weather Records. Washington, (Smithsonian Misc. Collections, Vols. 79, 90, 105).

(מקור הנתונים)

טבלה זאת כוללת ערכי טמפרטורה ממוצעים לתקופות עוקבות של עשר שנים. היא מראה כי מבחינת התנודות בין התקופות השונות עומדת בירות—תחנה קרובה לארצנו ובעלת סדרה ארוכה של תצפיות—בין גרינויץ' שהיא בעלת אקלים ימי ובין מוסקוה המצטינת באקלים יבשתי [ראה (א) ו (ב) בטבלה א']. ממוצעים חדשיים לתקופות דומות נתונים כמוכן לתנודות גדולות יותר—עובדה שיש להביאה בחשבון בשעת השמוש בערכים האלה. התנודות בערכים חדשיים הן קטנות בחדשי הקיץ וגדולות בעונת

* Conrad V. and Pollak L. W. (1950) Methods in Climatology, 2nd ed. Cambridge, Mass. Harvard University Press. p. 238.

* ר א ה

ה ק ד מ ה

לאור הדרישות הרבות לממוצעים מטאורולוגיים רב שנתיים, דרישות אשר חזרו ונישנו ביחוד בשנים האחרונות לצרכי מחקר ותכנון חקלאי ותעשיתי, החליט השרות המטאורולוגי להוציא לאור ערכים נורמליים אלה המבוססים על תצפיות תקינות במספר ניכר של תחנות נבחרות בארץ ישראל. אם כי ממוצעים אלה הם בחלקם "ארעיים", כפי שמוסבר במבוא, הם יכולים בכל זאת לשמש בסיס נאמן לכל מטרה בה יש צורך להתחשב בנתונים אקלימיים.

הנתונים הושגו ברובם מתחנות השרות המטאורולוגי מתקופת המנדט, ובחלקם מן המחלקה המטאורולוגית של האוניברסיטה העברית, מחברת האשג הא' בע'מ ומן המשרד המטאורולוגי של מיניסטרוך האוירה בלונדון.

כל הממוצעים הרב שנתיים הוכנו ע"י עובדי מדור האקלים של השרות המטאורולוגי.

מ. ג ל ע ד

מנהל השרות המטאורולוגי במדינת ישראל

ינואר 1952

ת ו כ ן

מבוא	עמ' 1
טבלה I : כמות הגשם החדשית והשנתית הממוצעת	3
" II : " " " " הממוצעת באחוזים	"
מן הכמות השנתית	9
III : מספר ממוצע של ימי גשם	9
IV : טמפרטורת המקסימום הממוצעת	11
V : " המינימום	11
VI : טמפרטורה יומית ממוצעת	12
VII : תנודה יומית ממוצעת של הטמפרטורה	12
באורים לטבלות VIII ו- IX	13
טבלה VIII : טמפרטורת המקסימום המחלטת	14
IX : " המינימום	15
X-X : הלחות היחסית הממוצעת	18-17
XI : ההתאדות היומית הממוצעת	19
XII-XIIa : כמות העננים הממוצעת	21-20

מדינת ישראל
משרד התחבורה
השרות המטאורולוגי

סדרה א'

רשימות מטאורולוגיות מס' 2

ממוצעים אקלימיים רבשנתיים

חלק ראשון



551.582.2
(569.4)

ירושלים תשי"ב 1952

Dr. Ben-Zion

STATE OF ISRAEL
MINISTRY OF TRANSPORT AND COMMUNICATIONS
METEOROLOGICAL SERVICE

Series A
METEOROLOGICAL NOTES No. 4

CLIMATOLOGICAL DATA FOR THE NEGEV



551.582.3
(569.4)

JERUSALEM 1952

FOREWORD

On the occasion of the International Symposium on Desert Research, Jerusalem, May 7-14 1952, the Israel Meteorological Service wishes to present these Data on the Climate of the Negev. Only stations which have been operating for a number of years are included. Part of the data on which the figures are based may be found in the Climatological Normals published by this Service.* Other data, referring to stations functioning since 1949, may be found in our current monthly and yearly publications.

Great difficulties have been, and still are encountered when attempting to obtain reliable climatic data for a mainly unsettled area like the Negev. First observations of both rainfall and other climatic elements were made at Gaza and Beersheba, the main centres of population in the area. Later, D ad Sea South was put into operation and in 1945 another station was erected at the northern end of the Gulf of 'Aqaba, 2 km east of what is now Eilat. Both of these stations were operated together with the Palestine Potash Ltd. A great part of our knowledge of rainfall conditions in the area is due to observations carried out at the police posts functioning in the area during the time of the Mandate.

Detailed knowledge of the climatic peculiarities of the Negev is a prerequisite for the planning of future activities there. Hence, investigation of the climate of the region was given a new impetus by the declaration of the State of Israel in May 1948. Since that time, 35 rainfall stations and 7 climatological stations have been erected by this Service in the Negev alone. Even so, the Negev Highlands have largely remained a *terra incognita* upto the present.

As rainfall constitutes the most important climatic element under arid or semi-arid conditions, considerable efforts have been made by this Service to erect a network of accumulating rain gauges, properly protected against evaporation, to be inspected at the end of each rainy season. Unfortunately, few data have been secured by this means, owing to interference by nomads and other people. These data seem to indicate a rather even distribution of rainfall throughout the interior of the Negev.

The problem of white man in a hot desert reaches paramount importance in the eastern parts of the Negev. In the vicinity of Eilat very high maximum temperatures occur together with unusually strong and steady winds, a combination of factors imposing upon the heat regulating capacity of the human body a strain which in some cases is probably rarely exceeded in other hot desert areas of the world. This lends great significance to problems of indoor climate. It is the intention of this Service to assist in the investigation of this factor, thus helping to alleviate the climatic stress to which all people working for the development of the Negev are subjected.

This publication has been written and edited by Mr. J. Lorch, M. Sc., a member of our staff.

M. Gilead

Director, Israel Meteorological Service

May 1952

* Meteorological Notes No. 3: Climatological Normals, Part One, Jerusalem 1952.

INTRODUCTION

Distance from, and height above, resp. below sea level, are the dominant factors which outline four climatic zones corresponding to the four major geographical divisions. In addition, distribution of rainfall varies with the latitude.

I. The Coastal Belt.

Extending along the shore of the Mediterranean, this Belt is 10—15 km wide. Mean annual amounts of rainfall vary between 400 mm in the north and 200 mm in the south.* Both the daily and yearly range of temperature are small in comparison with conditions prevailing throughout the rest of the Negev. Another aspect of maritime influence is the high relative humidity and the small diurnal and annual variation of this element. The Coastal Belt gradually merges into the adjacent zone. Fog occurs occasionally during spring and early summer. Frost is rare.

II. The Lowlands.

This region includes the large area of rolling plains which leads to the Negev Highlands. At the latitude of Beersheba it extends eastward without break to the verge of the Great Rift Valley. Mean annual amounts of rainfall decrease from 300 mm in the north to 100 mm in the south.* Both the daily and the annual range of temperature reach high values, reflecting a degree of continentality which is confirmed by similarly large variations of relative humidity. During summer, prevailing winds are W to NW, the onset of the wind occurring progressively later in the day with increasing distance from the sea. As the loess, occupying most of this area, is characterised by a high degree of erodibility the free sweep given to the wind by the topography may involve a severe problem of wind erosion once the crust of the soil is broken up.—Nocturnal cooling may result in the formation of fog in some parts of the area, and frost is not infrequent.

III. The Highlands.

This triangular area is bounded in the south by the Israel — Egypt border; in the east by the 'Arava, and in the west and north by the Lowlands. Heights exceed 1000 m and snow is fairly frequent at this level. Mean annual totals of rainfall probably range between 50 and 200 mm, showing a fairly even distribution for any given period.* Other climatic elements are largely influenced by topography, with mean temperature decreasing with height. Efficiency of rain as reflected by the development of plants is certainly influenced by this factor to a marked extent.—Winds may be very strong in part.—Except for a small area, all the eastern watershed of the Negev drains into the Dead Sea, 390 m below M. S. L.

IV. The 'Arava.

This area forms part of the Great Rift Valley extending from the Red Sea to northern Syria. It varies in width between 25 km in the north and 10 km in the south. Mean annual amounts of rainfall decrease from about 100 mm at the watershed (210 m above M. S. L.) and north of it to 50 mm at the Dead Sea and 25 mm at Eilat.* The very high temperatures regularly reached during the summer are combined with the lowest relative humidities of Israel. Especially near Eilat, very strong and steady winds are encountered which deviate from the prevailing wind direction of the country owing to the N—S channel effect of the 'Arava. Evaporative power of the air generally reaches high values, reflecting local differences in the wind regime. Duststorms are frequent in the sandy areas of the southern 'Arava.

* Characteristics of Annual Rainfall Amounts for stations and periods of fig. 7 The following values are

included (in mm):	I — highest				II — median				III — lowest				IV — average			
	I	II	III	IV		I	II	III	IV		I	II	III	IV		
Gaza	810	360	106	395	'Asluj	170	86	52	100	Quseima	105	53	25	60		
Rafa'	367	206	24	189	Kurnub	192	x	x	x	Kuntella	68	20	0	25		
Beersheba	336	170	76	192	'Auja	285	65	25	89	Ras e-Naqb	38	14	9	18		
Dead Sea, South	141	50	19	54	'Ein Hasb	178	60	17	69	Eilat	43	17	7	22		

NOTES TO THE FIGURES.

A) Temperature.

Fig. 1 (p. 3): Maximum and Minimum Temperature. Increases of continentality is reflected by an increase of the daily range. Absolute and mean highest maximum temperatures at Gaza and Beersheba show the higher degree of homogeneity characteristic of the summer months, as contrasted with the transitional months of spring and autumn. During the latter, spells of khamsinic conditions occur rather frequently, bringing hot and dry weather. At Gaza, May and October show the highest mean daily range of temperature of the whole year. The concave run of the mean highest and absolute maximum temperatures synchronously with the convex part of the yearly curve of mean temperature is typical of most stations in this country. It reflects the steadiness of the sea-breeze which is strengthened by the pressure gradient establishing itself in this region during the summer in conjunction with a centre of low pressure over the Persian Gulf, which is a branch of the monsoon low of Asia. The predominantly maritime influence of these months reduces the interdiurnal variability of temperature.

Fig 2 a, b (p. 4,5): Hourly Frequency of Temperature. January and July, 1946 and 1947 combined, Eilat and Beersheba (all times are local time, i.e. G. M. T. + 2).

At Eilat there is no overlapping of temperature at any hour during the two months. At Beersheba only a few hours have similar temperatures; this in spite of the fact that in these years corresponding months differed markedly. Such discrete distribution of temperature is of course typical of continental climates.

Fig. 4 (page 8): Accumulated Degree-Days above 10°C. 1947 and 1947 for Gaza, Beersheba and Eilat.

Some attention has been drawn to this subject by date growers. The high total accumulating at Eilat clearly indicates the suitability of its climate for date palms. It may in part explain the presence, north of Eilat, of some specimen of *Hyphaena thebaica* (Del.) Mart—a dichotomously branching palm which there reaches its northern limit of distribution. During winter, the cold conditions prevailing at continental Beersheba involve a reduced accumulation of day degrees as compared with Gaza. During summer no marked difference between these stations can be discerned. The relation between heat units accumulated in 1946 and 1947 is similar at the three stations.

B) Relative Humidity.

Fig 3 a, b (p. 6,7): Hourly Frequency of Relative Humidity. January and July; 1946 and 1947 combined. Eilat and Beersheba.

There is much overlapping between the two extreme months of the year. Nevertheless, there is a distinct clustering at the higher and lower values for January and July respectively. There is also a clear difference between Eilat and Beersheba.

Fig. 5 (p. 8, 9): Monthly Mean Relative Humidity. Means for 0800 and 1400 hrs. L.S.T.

The daily range of this element, which is small at Gaza, increases with increasing distance from the sea. The annual range shows a similar trend, being 6 per cent at Gaza and 26 and 22 per cent at Dead Sea South and Eilat respectively. The summer maximum of monthly mean values at Gaza is only another aspect of the maritime influence mentioned above in connection with temperature. It is much more pronounced in the annual variation of mean lowest relative humidity (dotted line).

At Beersheba, 45 km from the shore of the Mediterranean, the summer maximum of relative humidity is much less pronounced than at Gaza. Nevertheless, it is still clearly discernible in the otherwise unexpected increase of relative humidity from June onward.—Further east, the summer maximum is completely (Eilat) or almost completely obliterated (Dead Sea South).

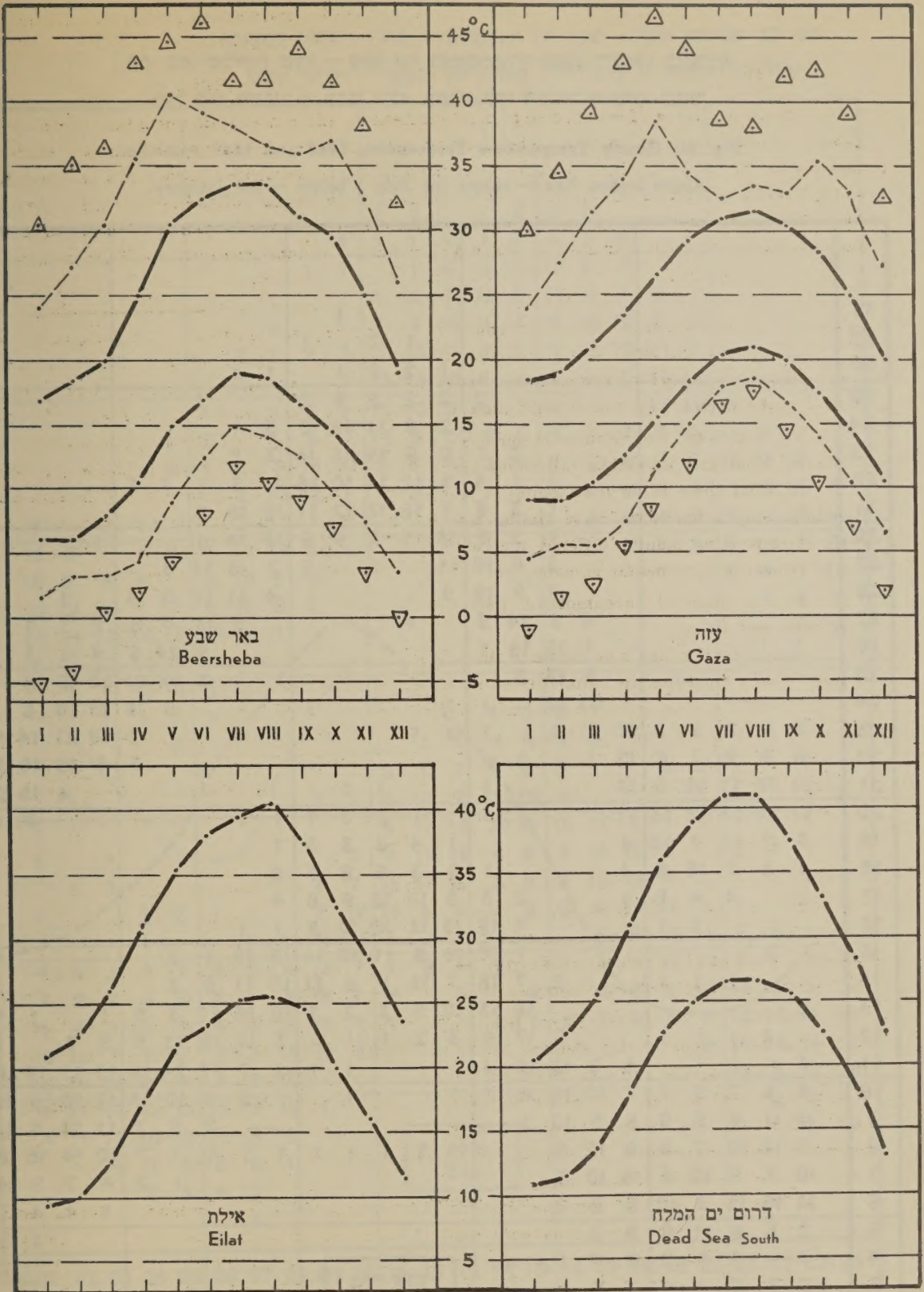
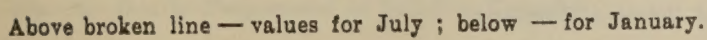


Fig. 1 Maximum and Minimum Temperature

תמ' 1: טמפרטורות מקסימום ומינימום

מקס. (מינ.) קיצוני $\triangle$ Absolute max. resp. min. ממוצעים חודשיים. —. Mean monthly values
ממוצע של הערך הגבוה (נמוך) ביותר. ---. Mean highest resp. lowest value



תמ' 3א: שכיחות שעה — שעה של לחות יחסית, 1946 ו-1947 במצורף.
למעלה — ינואר; למטה — יולי

%																								
95-100	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
90-95	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
85-90	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
80-85	1	2	2	2	3	4	4	5	1	.	.	.	.	1	.	.	.	.	.	.	.	.	1	1
75-80	3	3	1	3	6	7	8	7	4	.	.	.	.	1	.	.	.	.	.	.	.	1	2	1
70-75	4	7	10	14	13	11	9	11	4	2	.	.	.	.	.	.	.	.	1	3	3	1	1	1
65-70	7	7	12	8	4	4	8	6	9	5	4	1	1	.	.	.	.	1	.	2	2	3	3	7
60-65	11	7	2	1	5	8	5	6	4	7	2	.	1	.	1	1	2	1	3	1	3	4	8	8
55-60	3	6	9	10	9	5	5	3	10	10	4	4	.	1	1	1	1	2	3	10	7	7	9	7
50-55	7	4	6	3	6	4	4	5	6	5	8	4	5	1	.	1	1	2	8	5	11	10	4	4
45-50	6	8	6	7	4	4	5	6	3	6	5	8	4	4	3	1	2	9	5	9	3	6	7	8
40-45	6	4	1	1	3	4	5	5	4	4	8	5	8	7	6	9	12	8	8	7	9	8	8	5
35-40	3	4	5	4	1	2	2	4	8	5	9	11	7	11	12	12	10	7	11	5	5	4	5	6
30-35	5	4	3	3	5	6	5	3	4	10	5	9	10	7	6	3	4	8	5	10	6	6	6	7
25-30	3	5	4	4	1	2	.	.	3	4	6	7	9	10	12	12	13	10	11	6	9	6	4	2
20-25	2	.	.	1	1	.	1	1	1	3	5	10	7	7	8	10	6	8	6	5	3	3	1	2
15-20	.	.	.	.	.	.	.	.	1	.	2	3	9	9	8	7	8	6	2	1	1	.	1	.
10-15	.	.	.	.	.	.	.	.	.	1	.	.	1	3	5	5	3	.	.	.	.	.	.	.
5-10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
שעה	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Eilat												אילת												
90-95	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
85-90	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
80-85	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
75-80	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
70-75	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.
65-70	1	1	1	2	2	1	1	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	1	1
60-65	.	1	1	1	2	3	.	1	.	.	.	.	1	.	.	.	.	.	.	.	2	1	1	.
55-60	1	2	3	2	3	3	4	1	2	.	.	.	.	.	1	1	2	3	2	2	3	4	2	1
50-55	2	2	4	7	8	10	9	6	2	3	1	1	.	.	.	2	2	1	3	2	2	3	.	1
45-50	8	8	8	7	7	7	7	9	3	1	1	1	.	.	2	1	3	2	2	3	3	.	4	5
40-45	3	6	4	7	10	9	6	4	11	1	2	1	.	1	2	1	2	3	2	5	2	4	5	5
35-40	14	14	16	17	14	14	12	10	4	17	5	3	6	7	4	2	3	2	2	2	5	6	7	9
30-35	12	11	11	6	7	6	10	13	13	5	14	15	4	3	3	7	5	2	3	4	4	10	14	16
25-30	7	6	7	8	5	4	6	7	10	10	8	6	7	3	2	3	1	3	6	6	10	12	10	8
20-25	11	8	5	4	3	4	5	6	7	9	9	14	9	14	11	5	5	7	9	8	10	7	8	9
15-20	1	2	2	.	.	.	1	3	5	7	8	7	14	12	14	13	13	9	10	15	12	11	5	5
10-15	1	.	.	.	.	.	1	1	4	8	8	12	12	12	16	13	13	10	4	6	3	3	1	1
5-10	.	.	.	.	.	.	.	.	.	2	3	3	5	7	8	6	8	11	8	9	2	.	.	.
0-5	.	.	.	.	.	.	.	.	1	.	1	1	2	1	2	4	4	4	3	1	.	.	.	.
hour	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

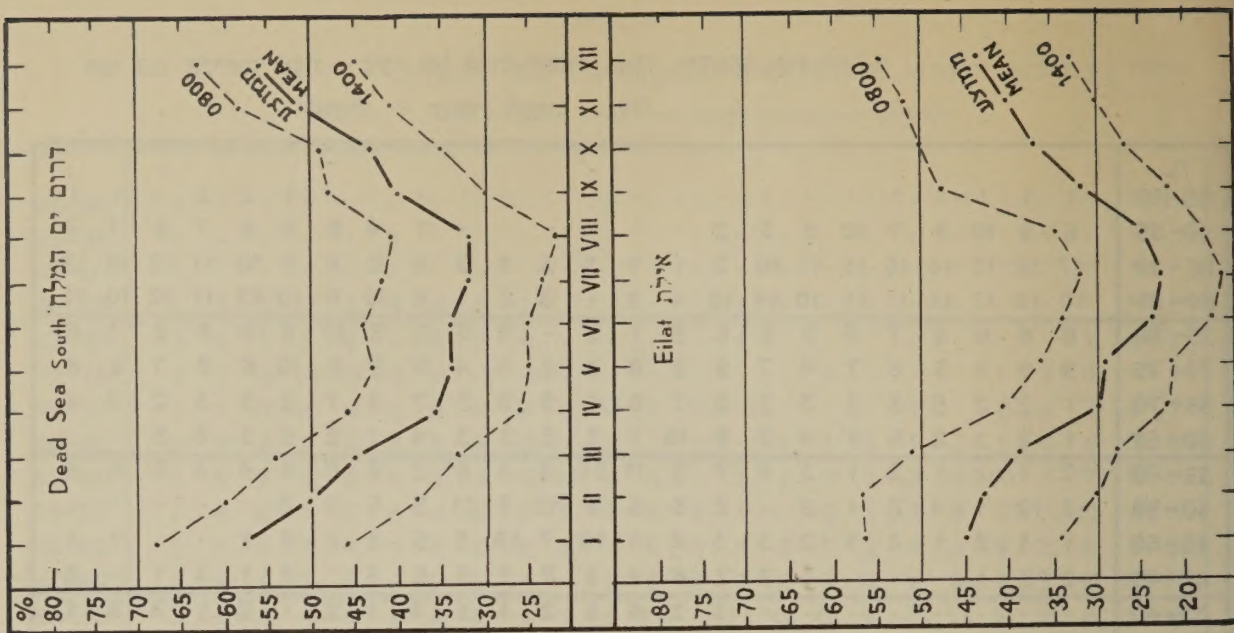
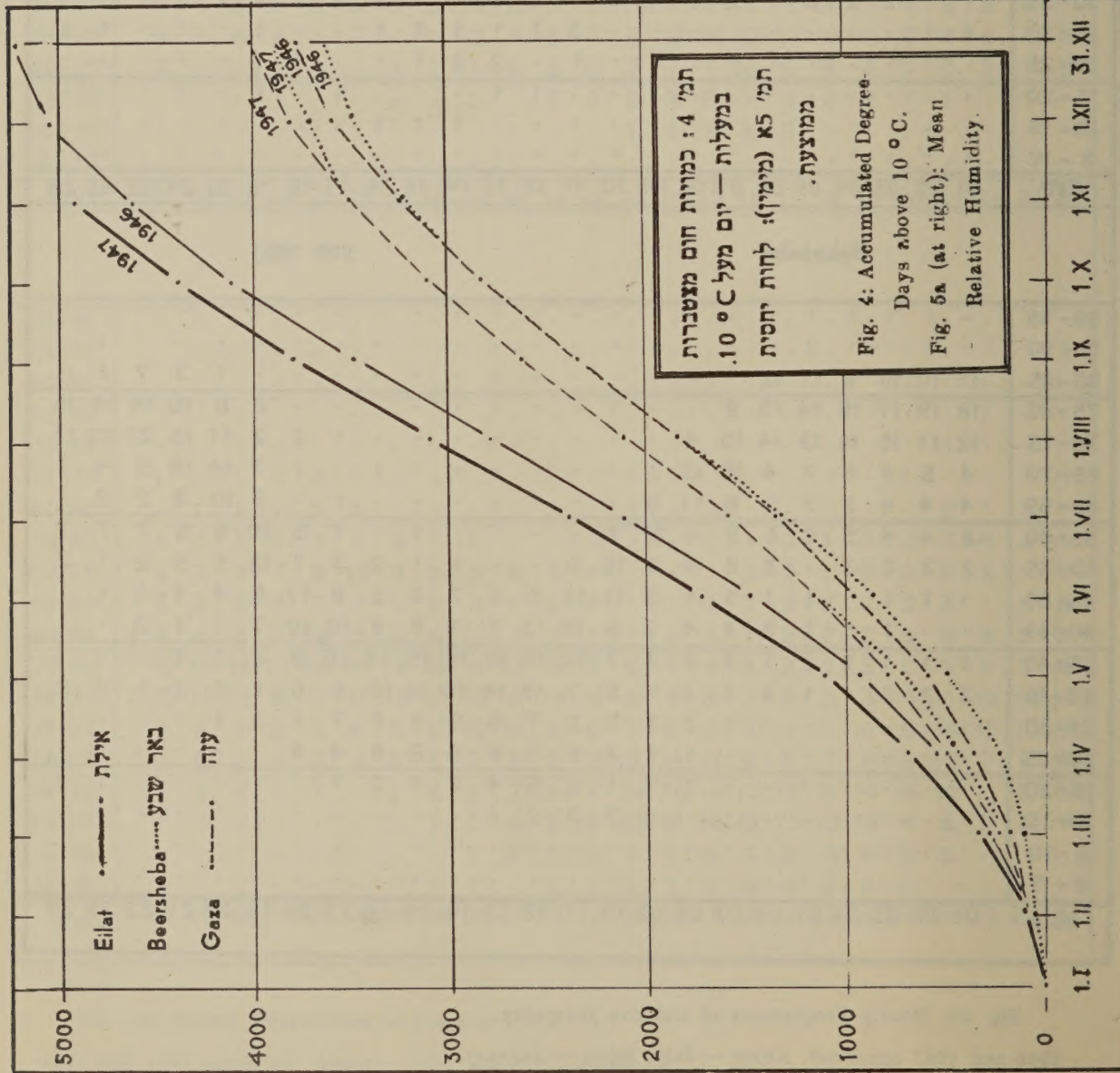
Fig. 3a: Hourly Frequencies of Relative Humidity,

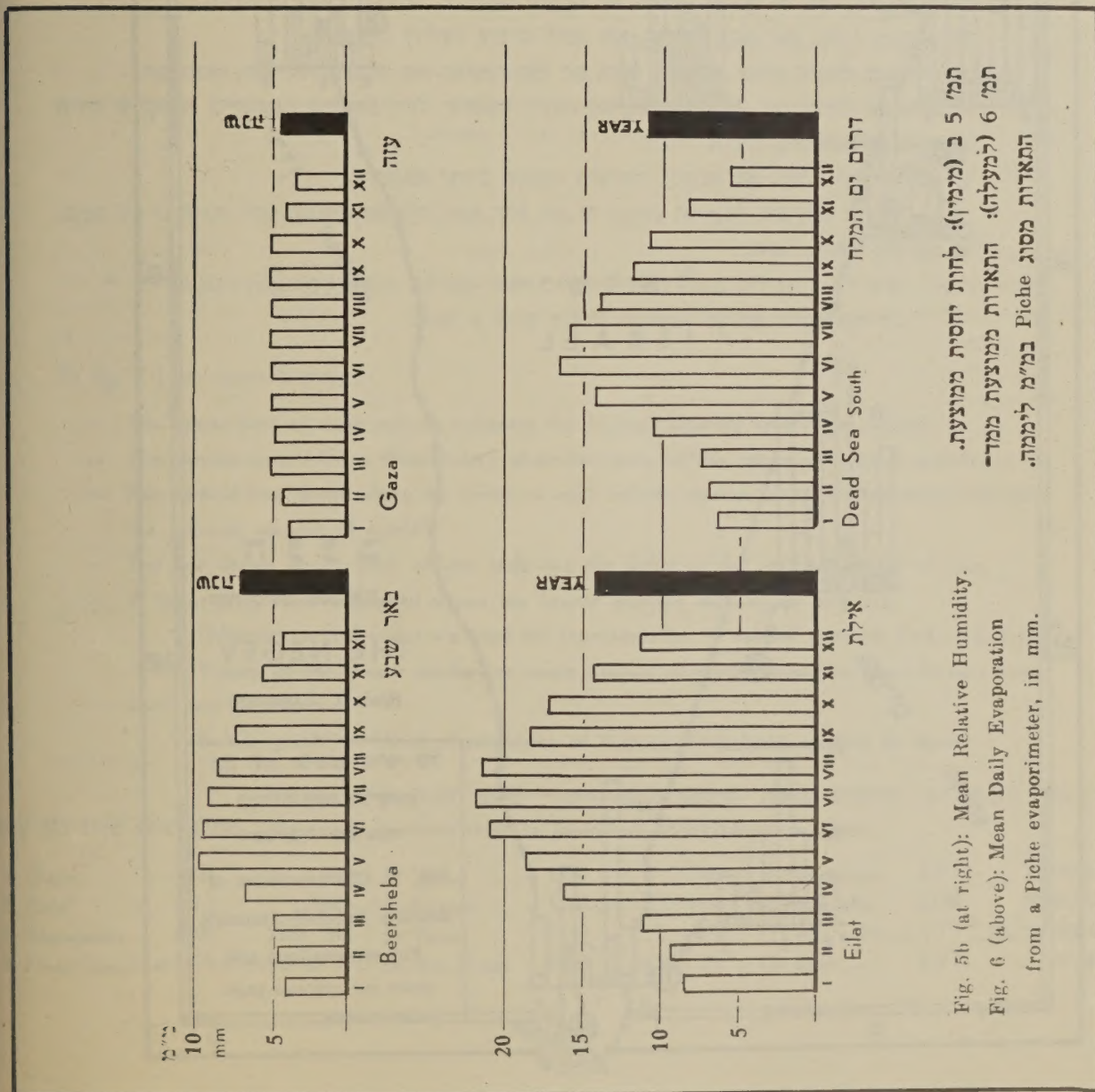
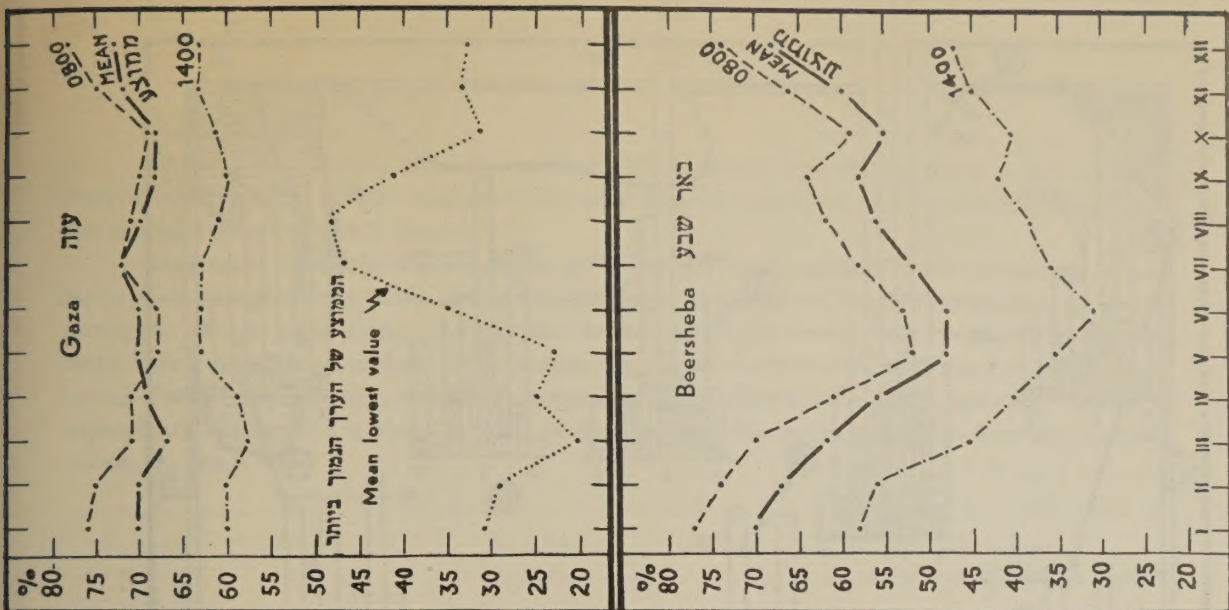
1946 and 1947 combined. Above — July; below — January.

תמ' 33: שכיחות שעה — שעה של לחות יחסית, 1946 ו-1947 במצורף.
למעלה — ינואר; למטה — יולי

%	1	1	1	1	1	.	.	1	.	.	.	.	.	.	.	.	1	2	2	.	1	1		
95-100	6	9	10	8	7	10	5	3	3	.	.	.	.	.	1	4	8	6	6	7	8	7	9	
90- 95	17	12	12	14	16	15	17	10	3	1	1	3	3	3	3	5	5	6	8	10	11	12	15	13
85- 90	10	12	12	12	11	11	10	14	10	4	2	.	3	2	1	6	10	8	10	13	11	12	10	11
80- 85	8	6	6	6	7	5	9	8	6	6	1	3	.	3	5	5	5	10	8	9	6	8	7	6
75- 80	9	9	9	6	6	7	4	7	8	8	9	3	2	4	4	5	9	5	10	5	8	7	8	8
70- 75	1	2	2	5	3	2	3	3	9	7	6	5	9	5	5	7	3	7	8	3	3	2	3	4
65- 70	1	3	2	2	3	5	4	3	5	10	7	5	3	3	3	4	1	2	9	3	6	3	.	.
60- 65	2	1	2	1	2	1	3	6	7	8	11	11	4	4	6	2	8	6	4	4	3	5	6	4
55- 60	2	2	1	4	2	1	2	.	2	5	6	8	12	9	11	5	5	3	3	.	.	.	.	.
50- 55	1	1	2	1	2	3	2	3	3	2	5	10	7	10	5	5	3	2	5	2	.	.	1	1
45- 50	2	2	1	.	.	.	1	3	2	6	4	3	7	7	5	6	3	.	2	1	1	1	.	2
40- 45	.	.	.	.	.	.	.	3	2	5	5	2	4	5	4	1	2	.	2	1	3	2	1	
35- 40	.	1	2	2	2	1	2	1	1	3	1	2	6	4	5	5	4	2	3	2	3	1	1	1
30- 35	2	1	.	.	.	.	.	.	.	3	3	1	1	2	1	.	.	1	.	.	.	1	1	
25- 30	.	.	.	.	.	.	.	.	.	1	.	2	2	1	.	.	1	1	.	.	.	.	.	.
20- 25	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	1	.	1	.	.	.	.	.
15- 20	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	1	.	1	.	.	.	.	.
10- 15	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	.	.	.	.	.	.	.	.
5- 10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
שעה	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Beershebaבאר שבע																								
90- 95	.	1	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
85- 90	.	1	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
80- 85	13	10	10	8	11	12	.	.	.	.	.	.	.	.	.	.	.	.	1	3	7	6	11	
75- 80	18	19	17	18	14	13	8	.	.	1	.	.	.	.	.	.	.	2	6	10	14	14	15	
70- 75	12	11	15	16	13	14	15	4	.	.	.	.	.	.	.	1	2	2	11	15	22	22	17	
65- 70	4	5	4	5	7	4	15	25	3	.	.	.	.	.	1	.	1	7	14	16	5	4	7	
60- 65	4	4	4	2	2	2	6	11	9	.	.	.	.	.	.	1	.	9	10	3	2	2	.	
55- 60	6	4	4	5	6	6	5	4	21	7	.	.	.	.	1	.	1	6	10	6	5	7	7	7
50- 55	2	3	2	3	.	3	2	4	9	15	3	.	.	1	1	2	3	7	13	5	5	2	1	2
45- 50	.	1	1	.	1	1	1	1	3	11	13	4	6	7	3	5	8	17	6	4	1	1	1	.
40- 45	.	.	1	1	2	2	3	4	2	6	14	13	7	7	8	9	10	10	7	1	1	2	.	.
35- 40	1	1	1	2	2	1	2	2	3	7	12	13	15	19	15	13	20	9	2	1	1	.	1	1
30- 35	2	2	2	1	1	4	4	3	5	5	7	15	14	10	16	16	6	6	1	2	2	1	2	2
25- 30	.	.	.	.	.	.	1	2	3	2	2	7	9	8	9	6	7	1	3	1	.	.	.	.
20- 25	.	.	.	.	.	.	.	1	1	4	6	3	6	8	8	8	4	3	.	.	.	.	.	.
15- 20	.	.	.	.	.	.	.	1	1	1	2	5	4	2	1	2	1	.	.	.	.	.	.	.
10- 15	.	.	.	.	.	.	.	.	2	3	3	2	1	.	.	.	.	.	.	.	.	.	.	.
5- 10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
0- 5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
hour	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

Fig. 3b: Hourly Frequencies of Relative Humidity,
1946 and 1947 combined. Above — July; below — January.





תמ' 5 ב (מימין): לחות יחסית ממוצעת.
תמ' 6 (למעלה): התאדות ממוצעת ממד-
התאדות מסוג Piche במ"מ ליממה.

Fig. 5b (at right): Mean Relative Humidity.
Fig. 6 (above): Mean Daily Evaporation
from a Piche evaporimeter, in mm.

Fig. 7 (p 10): Characteristics of Monthly Rainfall Amounts.

The greater part of relevant data obtained in the Negev have been used in the preparation of this diagram. Most stations in the northern part of the area had, however, to be omitted for lack of space. Each column indicates the highest amount ever recorded during the month concerned, the average and median value of the available data and the smallest amount so far observed. While analysing the graphs, the different scales used for representation of rainfall should be noted. Similarly, the different periods of observation at individual stations should be kept in mind. Much of the unexpected variability of monthly amounts of rainfall must, in fact, be attributed to the inadequacy of the available data. For this reason, limits of the upper and lower quartile have only been entered for Gaza and Beersheba, with over 30 years observations.

At Gaza, with 42 years intermittently on record during the period 1869 - 1948, rain is confined to the period September - June incl. During September, only 5 cases of rain, yielding a total not exceeding 7.0 mm, have been observed. At all other stations there is a similar division of the year, with no rain at all during some months in summer.

At Gaza, the limit of the lower quartile exceeds zero only from October to March incl.; the median from October to April, and the upper quartile from November to March. It is evident from this that at Gaza the distribution of monthly amounts during the rainfall season is asymmetrical: The ascending limb of the annual rainfall curve, September-December, is much steeper than the descending limb, January to May.

The median of any month is smaller than the average. Disregarding months with an average rainfall not exceeding 20 mm, the deviation of the median from the average ranges between 17 (February) and 31 (March) per cent of the latter amount. The total number of rainy days averages 41.

Seasonal rainfall decreases both southward and eastward from Gaza.

Within the 45 km which separate Gaza from Beersheba seasonal rainfall decreases from almost 400 mm to about 200 mm, i. e. by approximately 50%. This reduction of the seasonal total is unequally divided between individual months. Disregarding months with an average rainfall not exceeding 20 mm, the average rainfall at Beersheba deviates from corresponding amounts at Gaza by 63, 57, 48, 42, and 38 per cent for November to March respectively. As a result of this, the peak of the seasonal distribution of rainfall is somewhat retarded, and the distribution itself becomes more symmetrical. This is in accord with a similar trend known to exist in the rest of the country. At Beersheba, too, average monthly amounts exceed corresponding median values, although the difference between them is more variable than at Gaza. The median exceeds zero from November to April incl., while only January has never suffered a total lack of rain.

The closeness of mean and median values at stations in the northern Negev indicates the higher dependability of rainfall as compared with similar amounts in the southern Negev. At 'Asluj, 75 km south of Beersheba, there is the only case (January) of the median markedly exceeding the mean.

The gradient of rainfall amount from Gaza southward is even steeper than along the line Gaza - Beersheba. At Rafah, 30 km SSW of Gaza, rainfall amount is similar to Beersheba, although the distribution of monthly amounts resembles the type of distribution described for Gaza. Rafa, 'Auja, Quseima, Kuntella, Ras e-Naqb and Eilat, roughly following the Israel-Egypt border from the Mediterranean to the Gulf of 'Aqaba, show an increasing degree of aridity. At 'Auja and Quseima, monthly amounts approaching 100 mm have occurred, and one or more months have monthly averages of about 20 mm. At the three remaining stations, monthly amounts never exceeded 32 mm, and the average monthly total varies between 0 and 8 mms. At Kuntella and Ras e-Naqb, all months but one have a median value not exceeding 0. From Gaza to Eilat, the average number of rainy days decreases from 41 to 7 per year. As far as can be seen from available data, March has relatively large amounts of rain. At both Quseima (9 years) and Ras e-Naqb (7 years) the highest average and mean values pertain to this month. At Rafa, 'Auja and Eilat monthly averages have a secondary peak in March.

Excepting Beersheba and Kurnub, all other stations in the interior of the Negev similarly show March rainfall amounts equalling or exceeding those of January.

LIST OF FIGURES	קמור page	תוכן הענינים
Fig. 1: Mean maximum and minimum temperature	3	תמ' 1: טמפרטורות מקסימום ומינימום
Fig. 2a,b: Hourly frequency of temperature	4,5	תמ' 2 א.ב: שכיחות שעה-שעה של טמפרטורה
Fig. 3a,b: Hourly frequency of relative humidity	6,7	תמ' 3 א.ב: שכיחות שעה-שעה של לחות יחסית
Fig. 4: Accumulated degree-days above 10 °C	8	תמ' 4: כמויות חום מצטברות במקלות-יום מעל 10 °C
Fig. 5: Monthly mean relative humidity	8,9	תמ' 5: לחות יחסית ממוצעת
Fig. 6: Monthly mean evaporation	9	תמ' 6: התאדות יומית ממוצעת
Fig. 7: Characteristics of monthly rainfall amounts	10	תמ' 7: סיכום גרפי של כמויות נשם הרשיות

רשימת הפרסומים של השרות המטאורולוגי

סדרה א': רשימות מטאורולוגיות

- מס' 1: נ. רוזנן וצ. שור - מדירת ההתאדות לפי שיטת Piche, 1951
מס' 2: ממוצעים אקלימיים רבשנתיים, 1951

סדרה ב': נתונים אקלימיים

- סיכום הרשי למזג האוויר יוצא לאור מאז נובמבר 1947, פרט לשנת 1948
סיכום שנתי למזג האוויר " " " " שנת 1948
סיכום שנתי לגשמים " " " " עונת 1947/48
סיכום שנתי לטללים " " " " שנת 1947

PUBLICATIONS OF THE ISRAEL METEOROLOGICAL SERVICE

SERIES A: METEOROLOGICAL NOTES

- No. 1. N. Rosenan: The measurement of evaporative power in Israel. 1951
No. 2. J. Neumann: Diurnal variation of low cloudiness in summer at two stations situated near coastlines of opposite curvature. 1951
No. 3. Climatological Normals, Part One. 1951

SERIES B: OBSERVATIONAL DATA

- Monthly Weather Report Published since November 1947 (1948 omitted)
Annual Weather Report Published since 1948
Annual Rainfall Summary Published since 1947/48
Annual Dew Summary Published since 1947

מדינת ישראל
משרד התחבורה
השרות המטאורולוגי

סדרה א'

רשימות מטאורולוגיות מס' 4

נתונים אקלימיים מהנגב



Dr. C. E. Kellogg

Eden Hotel

582.3

(569.4)

ירושלים תשי"ב 1952

May 11

We are up early in a warm, but misty morning. After a light breakfast we are in the busses at 7:30.

Beersheba is roughly on the border between the well-watered country to the north and dry country to the south. This border zone has fluctuated over the centuries, partly according to security. The site of the present city is near biblical Beersheba, where there were wells. At least one of these is now open. Two roads meet here from the north and one leads to Gaza. Now the armistice borders cut the roads to Gaza and to Hebron. Under the mandate the population of Beersheba was around 7,000; now it is over 20,000. Part of the people are refugees from Hebron and Gaza, now in Arab hands. Except for evidences of Arab and Mediterranean architecture and many steel oil drums, it looks like a typical "boom" town of the Great Plains. It is the principal administrative and commercial center for the Negev. Many new houses were made very rapidly from concrete. Although substantial, they are not attractive. Some were built in one or two days.

The rainfall is about 230 mm or 9 inches. Here in the lowlands the climate is more nearly continental than farther north. Summer temperatures run at about 95° in

the day with very low humidity. Diurnal variations are about 30°F. During April to June, winds occasionally drift in from the Mediterranean.

We have some delay while the busses take oil and gas. Then we drive south. Our bus drivers carry pistols and we have a military escort. For impression or because of the danger of hostile Arabs?

My first impression is that the soils belong with the Reddish-Brown group. Grasses dominate over shrubs. The soil color is brown to light brown. We just pass over undulating soil, the upper part of which is from loess. Hills in the background are rounded. Only a little of the soil is cultivated where we start.

The local plain is cut with dry gravelly wadis. We soon pass into irregular and broken country, cut by small dry wadis with steep cut-banks some 2 to 6 feet deep. It appears to be only lightly-grazed now. I suspect that much of the land has been used fairly recently for cereals, in irregular patches, and is now occupied by short, brown weeds.

As we go through a big opening in the hills, I see coarse broken rock at 3 to 6 inches below the wind-deposited material. At about four miles from Beersheba we pass undulating soil with barley in the favored places that have

received flood waters. I see a few goats kept by semi-nomadic Bedouins. In some road cuts through the low hills, the residual chalk comes to the very surface. I see an occasional recent shallow gulley and a few slips. One sees partial desert pavement in exposed places and a few wind drifts; but generally the soil is well stabilized by annual grasses and low weeds.

Around ten miles out from Beersheba we pass near low hills of nearly stabilized sand dunes, but with a few active blowouts and drifts. The center of this belt has a lot of open sand except for a few acres planted mainly to pine and eucalyptus.

At about $12\frac{1}{2}$ miles we leave the strip of dunes and are back into rolling country with irregular dissection and short steep slopes with exposed chalk. The surface material is mixed local wash and wind-blown material.

At 18 miles the hills to the side are somewhat bolder, with rather thin soft limestone or chalk country rock. The thin places have a very sparse cover but the surface is nearly stable. The road continues in a long small valley with low side fans and a few small shallow arroyos.

About 20 miles out we go over a low divide and enter an undulating plain some two to four miles wide. We enter the area of Masahabim, a kibbutz some two years old. The



K-2123 May 11, 1952
Near Masahabim. Looking down small wadi;
small rubble dam where people stand.



K-2124 May 11, 1952
Near Masahabim. Looking down old main wadi;
rubble dam at near left.

buildings are near a low gravelly wall with several small
entrances. I see a few young planted trees. A few new
buildings include a new building made for 3,000 men.

Here we leave the paved road for a desert track to
the southeast. A mile or so beyond the buildings we stop
to see a tiny dam on the wadi, made with ball masonry, to
reduce the velocity of the water and to spread it out for
pasture grass. The road here has a grade of about five
percent. The wall
crosses over gravelly
here.



We return to
the southwest. We
again, nearly stop

We continue the desert trail on this road.
The landscape is
red color.

K-2125 May 11, 1952
Near Masahabim. Looking up the wadi,
south into the hills.

We are invited to walk over the interesting ruins of
Subeita and eat a light lunch. Apparently this place had
a garrison in early times. They had wells and apparently
used spreaders to save some water from the wadis. But I
suspect that people in this old desert town, like there
is many others, lived mainly by either serving or robbing
travelers. Probably some of both.

buildings are near a low gravelly wadi with several side entrances. I see a few young planted trees. A few new buildings include a new poultry house for 3,000 hens.

Here we leave the paved road for a desert track to the southeast. A mile or so beyond the buildings we stop to see a tiny dam on the wadi, made with bulldozers, to reduce the velocity of the water and to spread it out for pasture grass. The wadi here has a grade of about five percent. The soil is a young light brown one from thin loess over gravelly and cobbly alluvium. I try for pictures here.

We return to the main road on the way to Subeita, to the southwest. We pass the ruins of an Arab village near medium, nearly stabilized sand dunes.

We continue for several miles on this local plain. The landscape suggests dry Reddish-Brown soil, with little red color.

We are invited to walk over the interesting ruins of Subeita and eat a light lunch. Apparently this place had a garrison in early times. They had wells and apparently used spreaders to save some water from the wadis. But I suspect that people in this old desert town, like those in many others, lived mainly by either serving or robbing travelers. Probably some of both.

From these old ruins, we go approximately north on a desert track. Most of the smooth soil here appears to have been plowed within the past few years. Some oats self seeded in the favored places. In places the desert track passes over beautiful desert pavement with varnish.

On one slope with pebbly desert pavement are small mounds, 20 to 30 inches high and 30 to 50 inches in diameter, that may be remnants of orchards centuries ago. A local scientist suggests that the roots of the trees held the soil around the old stumps. I think that it is more likely that the trees were mulched with small stones. Then as the desert pavement formed only a little soil would be blown from these spots where the trees stood before being stabilized by pavement.

We join the main road by which we came from Beersheba. Now it is warm and bright. We go east of the corner where the main road leads to Beersheba and enter a hilly region of limestone. There are many small stones on the surface and very little loess. (One can easily see why so much is said about throwing stones in the Bible. In much of the Holy Land they lie about abundantly.) The vegetation is short and sparse. East, beyond these hills, we pass over undulating soil of fairly fine texture.



K-2126 May 11, 1952
North of Subeita. Small mounds on fan with desert pavement marking location of old orchard trees.

We pass Tel-Yerukham (formerly Tell-Rakhma) and a little way beyond come to a transition camp (also called "maabara"), Yerukham, where we finish our lunch and have water. This place is about $1\frac{1}{2}$ years old. The people work on highways and in mines for phosphate rock and fire clay. The people are recent immigrants, mostly from the Balkans. The buildings are barely adequate.

From here we seem to go in a north and easterly direction over bad desert track. (Obviously we are far behind schedule!) From the bus, the soil appears to be gently rolling and undulating light brown sandy loam. The plant cover is fair to medium but is now becoming very dry. The surface soil is well stabilized with plants and partial desert pavement. After three to five miles the cover is thinner and the desert pavement more prominent with some rock outcrops.

In perhaps three or four miles more we pass through rather broken hills and enter a smooth valley. At the margin of the valley we are shown a small dam at Kurnud. I take a few pictures.

The excursion is terminated here and the busses start back to Beersheba. We return by a slightly different route to the transition camp, Yerukham.

I am beginning to see that the whole trip is "to see the country." We have had no stops at all to see the soil, although there were many new road cuts on this last road.

Here I notice some "sage" of Gully, but no visible evidence.
Near the camp, the horses stop and people are given some
orange drinks in the barrels. Our guides are around when
I ask, "Aren't we going to see any soil?" They thought
we had been looking for a stop or so. Nothing
for me to choose.

First, I stop
of trees to continue
twelve miles south.



Then we stop

or so south of K-2127, May 11, 1952
Kurnud. Small dam.
There has been some erosion. The vegetation is thin,
and there are a few small trees on the surface.

The soil is a yellowish-brown. If water were
available it could
be great waste.

The soil has

A₁ 0-8 1/2"

See 81-19/21



K-2128 May 11, 1952
Kurnud. Well-stabilized valley with only
slight erosion, grazed with goats and camels.

Here I notice some "eyes" of CaCO_3 , but no croute calcaire. Near the camp, the busses stop and people are given some orange drinks in the busses. Our guides are amazed when I ask, "Aren't we going to see any soils?" They thought we had been looking at soils! They say I can arrange a stop or so. Nothing had been planned, and it will be hard for me to choose a good place.

First, I stop to get pictures of the new plantings of trees to control blowing in the big sandy area some twelve miles south of Beersheba.

Then we stop on an old stabilized fan some ten miles or so south of Beersheba. The slope is around 5 to 6 percent. There has been some dissection. The vegetation is thin, and there are a few small stones on the surface.

The soil is a youthful Reddish-Brown. If water were available it could be irrigated. I look at the profile in great haste.

The soil has a very thin "desert crust."

A₁ 0-8 $\frac{1}{2}$ " Light brown to reddish-yellow (7.5YR 6/5) fine sandy loam. Very weak irregular blocky and granular, mixed. Friable.

B_{ca} 8 $\frac{1}{2}$ -19/24 Reddish-yellow (7.5YR 7/6) moist (now) loam with imperfect, irregular, blocky and granular mixed. Fairly friable but more firm than above. A few "eyes."

13/24 - 30% Reddish-yellow (7.5/2.5) clay
fine sandy loam. Total am. 100%
siltstone/loam. Probably water loam.

We go on to Beersheba and then take a tour (one hour
to see) of the modern part of the city. I'm told that the
present city was founded in 1909 by Bedouins. About 1930
Jewish settlement started.

settlement started

We are back in

in a downtown rest

back and get to be

very back. I sh



K-2129 May 11, 1952

About 12 miles south of Beersheba. New
plantings stabilizing dune sand, mostly eucalyptus.



K-2130 May 11, 1952

10 miles south of Beersheba. View of reddish-
brown soil on old fan-covered with loess.

May C 19/24 - 30" Reddish-yellow (7.5YR 7/6) heavy
fine sandy loam. Moist now. Nearly
structureless. Probably coarse loess.

We go on to Beersheba and then take a tour (unwelcome
to me) of the modern part of the city. I'm told that the
present city was founded in 1900 by Bedouins. About 1930
Jewish settlement began on an experimental basis. Rapid
settlement started in 1946.

We are back to our barracks about 5:30. We have dinner
in a downtown restaurant. It goes very slowly. I walk
back and get to bed about 10:15 with mosquitoes and a very
sore back. I shouldn't want this room many nights.

The soil is examined in a range of places, but has
been disturbed.

- | | | |
|------|--------|--|
| A11 | 0-4" | Weakly pitted, light yellow-brown (10YR 8/6)
fine sandy loam. |
| A12 | 4-14" | Light yellow-brown (10YR 8/6) fine sandy
loam with thin, faint, wavy, wavy
primarily along the surface, wavy. |
| B3ca | 14-32" | As above but slightly more clay and more
firm. Moderate, wavy, wavy. |
| B3ca | 32-36" | Transition. |
| B | 36-40" | Yellow (10YR 8/6) light clay sandy loam;
Some "typical" of 10YR 8/6, wavy, wavy, wavy,
slight granular wavy, wavy, wavy, wavy. |

1/ In great haste, because all stops are in the ground,
and only Aubert and I are left interested.

May 12

This morning is warm and dusty. We were fortunate to have gone south yesterday. We are in the busses to start north at 7:50.

Almost immediately we enter an undulating mildly-dissected plain of Reddish-Brown soils from coarse loess (?). I see some cereal stubble and much fallow. Plantings of eucalyptus border the highway.

About 10 miles north of Beersheba, I look very hastily at the profile of this youthful Reddish-Brown soil on a slope of two to eight percent. The surface has a few small stones. ^{1/}

The soil is examined in a fairly good road cut, but has been disturbed.

- | | | |
|------------------|----------------------|---|
| A ₁₁ | 0-4" | Weakly platy, light yellowish-brown (10YR 6/4) fine sandy loam. |
| A ₁₂ | 4-14" | Light yellowish-brown (10YR 6/4) fine sandy loam with firm, friable, vesicular, weak prismatic-blocky and granular, mixed. |
| B _{2ca} | 14-32" | As above but slightly more clay and more firm. Moderate, medium, prismatic-blocky. |
| B _{3ca} | 32-36" | Transitional. |
| C | 36-40" ^{1/} | Yellow (10YR 7/6) light fine sandy loam. Some "eyes" of CaCO ₃ . Nearly massive, with slight cracking when dry. Very easily friable. |

^{1/} In great haste, because no soil stops are in the program, and only Aubert and I are much interested.

Roots penetrate into the S. Slight concentration of clay in the S. The soil is essentially so red in this soil. Throughout the profile, the soil is ventricular.

We drive on north. I see fair fields of wheat with 15 to 25 bushels per acre. Barley is being combined. Yields of cereals are poor on slope phases greater than 6 percent. On the margins of the deep drainageways, chalk is exposed.

Some 15 miles more red and some suspect we are just we stop 17 miles

On one side the other is a small den has



K-2131 May 12, 1952
10 miles north of Beersheba. View
where reddish-brown soil described.

to regularize the In a sense the Jan is experimental (1) to learn how to hold in stages; from local material (2) to learn how to hold in stages; and (3) to get experience in flood protection. The slopes on the sides of the wall are well stabilized with small stones. On the slopes I notice small holes, or blow-holes, from the settling of the limestone. It is said that on the average nine percent of the rainfall here runs off.

Roots penetrate into the C. Slight concentration of clay in the B. One sees essentially no red in this soil. Throughout the profile, the soil is vesicular.

We drive on north. I see fair fields of wheat with 15 to 25 bushels per acre. Barley is being combined. Yields of cereals are poor on slope phases greater than 6 percent. On the margins of the deep drainageways, chalk is exposed.

Some 15 miles north of Beersheba, the soil becomes more red and seems likely to have more clay in the B. I suspect we are just passing into the Reddish Chestnut when we stop 17 miles north of Beersheba.

On one side of the road is a kibbutz -- Shuval. On the other is a camp of semi-nomadic Bedouins. On that side a small dam has been built to store water for irrigation and to regularize the "eastern" pipe line. In a sense the dam is experimental: (1) to find out how to make a firm base from loessial material; (2) to learn how to build in stages; and (3) to get experience in flood protection. The slopes on the sides of the wadi are well stabilized with small stones. On the slopes I notice small holes, or micro-dells, from the settling of the limestone. It is said that on the average nine percent of the rainfall here runs off.

Soil erosion control specialists with long experience have helped the kibbutz (Jewish) in developing a system of farming to reduce runoff through terraces and without cultivation. The water runs good. Here the soil is very permeable.

Another way
cattle. Most of
the straw is baled
each day. It's baled
average. The soil
measures; it's only



that are thin and are avoided.

K-2132 May 12, 1952

About 17 miles north of Beersheba. Group of nomads' tents.

As we go on the road, we find a series of small, rectangular structures, likely tents or huts, scattered across the landscape. The terrain is dry and open, with some low-lying vegetation.

in clay. This may be partly a matter of greater distance from the source of the water and partly a matter of the clay formation.

clay formation is

10 bushels per acre

On slopes of

are thin.

The erosion

than at Shoval, a

permeability of

expected to be



K-2133 May 12, 1952

About 17 miles north of Beersheba. Group of nomads' tents. Note micro-limestone sinks.

K-2132 May 12, 1952
About 17 miles north of Bethesda. Group of
nomads' tents.

K-2132

K-2133 May 12, 1952
About 17 miles north of Bethesda. Group of
nomads' tents. Note micro-limestone mounds.

K-2133

Soil erosion control specialists with Lowdermilk have helped the kibbutz (Jewish) to develop a system of farming to reduce runoff through terraces and contour cultivation. The work looks good. Here the soil is very permeable.

Another two miles north we pass a herd of Friesian cattle. Most grain here is harvested with a combine and the straw is baled. The grain looks quite good for country so dry. I'm told that the season has been better than average. The soil is nearly ideal with simple water-control measures; if soils with slopes over six percent and soils that are thin over the country rock are avoided.

As we go north, the soil continues to become richer in clay. This may be partly a matter of greater distance from the source of the loess and partly a matter of more clay formation in situ. We pass oats that look to be 60 bushels per acre.

On slopes more than 5 or 6 percent, the A horizons are thin.

The erosion hazard is greater on cultivated soil here than at Shuval, a few miles back, because of the lower permeability of the B horizon. Grain sorghum might be expected to do well here.

I'm told that the soil organic matter was only about 1 percent in the plowed soil. Certainly nitrogen fertilizers, especially di-ammonium phosphate, would be used here. Yet I suspect, from the appearance of the crops, that some of them are reasonably well supplied with nitrogen, at least.

We stop for a moment. Here is gently undulating land. I'm told that until recently there was a small dam and pool here. The main fall is



We turn left. K-2134 May 12, 1952
About 17 miles north of Beersheba. Small dam and pool. Arab tent immediate foreground.

field of sorghum and some large areas of sunflower. But most of the crops are cereals with some maize. The maize that is now deficient.

A little north of here is an area that appears to be irrigated and is now being used for dry farming. Irrigation is to



K-2135 May 12, 1952
About 17 miles north of Beersheba. Cereals with strip cropping on reddish-brown soils.

I'm told that the soil organic matter runs only about 1 percent in the plowed soil. Certainly nitrogen fertilizers, especially di-ammonium phosphate, should be used here. Yet I suspect, from the appearance of the crops, that some of these Reddish-Chestnut soils are reasonably well supplied with phosphorus and need only nitrogen, at least with dry farming.

We stop for a moment about $3\frac{1}{4}$ miles north of Beersheba. Here is gently undulating soil with very good cereals. I'm told that until recently there was little regular farming here. The rainfall is now about 400 mm (16 inches).

We turn left off the main road on Reddish Chestnut soil and go generally south of southwest. I see a small field of sesame and one or two large ones of sunflowers. But most of the crops are cereals with some maize. The maize that is more than 18 inches high shows mild nitrogen deficiency.

A little north of Ruhama we enter a hilly, dissected area that appears to have been badly overgrazed at one time and is now being stabilized by weeds. There is both irrigation and dry farming in the favored places. Alfalfa under sprinkler irrigation is in only fair stand. Irrigated vegetables are from old dunes appear. But the crops are mainly cereals, with a few scattered orange orchards.

I'm told that the soil organic matter runs only about 1 percent in the plowed soil. Certainly nitrogen fertilizers, especially di-ammonium phosphate, should be used here. Yet I suspect, from the appearance of the crops, that some of these Reddish-Chestnut soils are reasonably well supplied with phosphorus and need only nitrogen, at least with dry farming.

We stop for a moment about 3 1/2 miles north of Berrah. Here is gently undulating soil with very good cereals. I'm told that until recently there was little regular farming here. The rainfall is now about 100 mm (10 inches).

We turn left off the main road on Reddish Chestnut soil and go generally south of southwest. I see a small field of sesame and one or two large ones of sunflowers. But most of the crops are cereals with some maize. The maize that is more than 18 inches high shows mild nitrogen deficiency.

A little north of Rabana we enter a hilly, dissected area that appears to have been badly overgrazed at one time and is now being stabilized by weeds. There is both irrigation and dry farming in the favored places. Alfalfa under sprinkler irrigation is in only fair stand. Irrigated vegetables are

a bit better. I see nice plantings of vines and fruits on the slopes. A small reservoir has been built for water storage. The children are now using it for swimming.

The Ruhama kibbutz is 15 years old. Rainfall here is about 350 mm (14 inches). I'm told that the dam holds about 25 acre feet of water. An electric pump is used for irrigating alfalfa, vegetables, and fruit. Electric fences are used to regulate grazing of alfalfa-grass pastures. The steep slopes in the little watershed are planted to trees and not grazed. I see a large group of poultry houses in the kibbutz.

We have a very much needed drink of water and go back north over the same road. Unfortunately, no opportunity was provided for us to meet the people of the kibbutz. It looks fairly prosperous and the people seem to be working hard. One secret of the kibbutz is to have everyone well and able to work hard.

We pass Julis and continue toward Rehovot. Beyond Julis we enter into a large smooth area that appears to be clayey alluvium. A bit north of it are new settlements for people moved in from Hebron since the 1948 war.

As we go north, some spots of the "red sandy" soils from old dunes appear. Yet the crops are mainly cereals, with a few scattered orange orchards.



K Is. 6.8 May 12, 1952
Ruhama. Vineyards and fruit on contour. Reddish
Chestnut soil. 15-year-old Kibbutz.



K-2136 May 12, 1952
Ruhama. View from the orchard, looking
across the reservoir to the main buildings
of the kibbutz.

We pass Ramat about 12:35 p.m. Now we have large
 bodies of the "red sandy" hills, along with clayey alluvium.
 I'm not sure of the hills on the easy upward slopes. Woods
 are bad. Some fields are fallow.

Here I see
 to protect citrus

We stop at
 Rahmat for orange

This is followed
 wife of the sick
 that she has read



K-2137 May 12, 1952
 Ruhama. View in the kibbutz.

We take a
 "pure" research

Facilities are
 or old-style

Sections of
 applied work

that Israel was



K-2138 May 12, 1952
 Ruhama. The fronts of two apartments in the
 kibbutz.

I walk over to the agricultural experiment station and
 have a session with
 principles in soil science.

We pass Masmia about 12:35 p.m. Now we have large bodies of the "red sandy" soils, along with clayey alluvium. I'm not sure of the soils on the easy upland slopes. Weeds are bad. Some fields are fallow.

Here I see many acacia and cyprus windbreaks, especially to protect citrus.

We stop at the agricultural experiment station in Rehovot for orange juice and other refreshments at 1:00 p.m. This is followed by a reception given by Mrs. Weizmann, wife of the sick president. I am a bit surprised to find that she has read several of my papers and also the Proceedings of the Symposium on Desert Research in Jerusalem. She asks me to have lunch at her table and we discuss many of the land and social problems of Israel.

We take a brief look at the Weizmann Institute, a "pure" research institute. Chemistry gets great emphasis. Facilities are excellent; but the atmosphere is a bit snobbish, or old-style European. Apparently the boys here are very jealous of their "pure" scientific standing and feel that applied work would destroy it. This is a pity and I wonder that Israel can afford the luxury.

I walk over to the agricultural experiment station and have a session with several of the young men about general principles in soil science.

We leave Rehovot about 4:00 p.m. and drive north in the coastal plain. We pass large areas of Alluvial soils, many of which are reddish and clayey. Some of these are too wet for citrus. With the many new villages, the area is thickly settled. Most of the villages are on the "red sandy" soils.

We pass Ramataim. I still see small areas of Alluvial soil. As we go further north I see many sandy soils along this road. Other soils are quite clayey. We pass cereals, fruits, irrigated vegetables, and fallow.

Several miles beyond we pass through a large area of only partially fixed recent sand dunes. We stop at Caesarea, an old Roman city, used later by the crusaders. (See Reifenberg's The soils of Palestine) The Romans were said to have had a good drainage system. Under the Arabs this went to pieces, but was opened some 25 years ago. (Reifenberg explains how the building of a mole increased the accumulation of sand at the beach, which blew over the town and covered it. On the north, it caused wave cutting.) We wander about among the ruins of the old seaport. Here is a mixture of Roman, Byzantine, Crusader, and Arab. But by now, I'm far too tired to enjoy it.

Finally we are back in the busses for a long tiring ride to Haifa in heavy traffic that reminds me of the terrible

Baltimore Boulevard. We are split among three hotels, and mine is last. After two very long and needless waits, my usual patience finally gives out! At last I'm at the Nof Carmel -- my hotel. By skipping dinner I have a bath and get to bed a bit after 10:00 p.m. Very tired. for the first time in Israel.

The buses leave about 8:30. As we drive down the slope of Mt. Carmel we have a grand view of the whole harbor of Haifa and of the industrial area built on a reclaimed swamp. Looking back on the footslopes from the plain, the soil appears to be Terra Rossa-lithomel. The soil is now being planted to forest. Old springs along the foot-slopes testify to the water collection of cracked limestone. Formerly the great swampy areas along the river here led to much malaria.

The air is now hazy from the hot easterly winds. On the patches of upland the old oaks, formerly suppressed by Arab goats, are now growing into trees. At least part of these low uplands have Rendzina soils.

We go on east over undulating country with very dark brown soil, probably Rendzina-Alluvial. I see wheat, oats, vetch fallow, and some vetch sugar beets. I see some young maize.

We continue east over another low ridge and pass Rashtashai. The cover includes alfalfa, wheat, and some

May 13 with cereals and vegetables in the favored places.

I'm up at 6:00 after a fairly good sleep, although still tired. The wind blew hard last night and still blows strong from the east -- the "hamsim" -- so this will be a hot day. I have a good breakfast, with porridge for the first time in Israel.

The busses leave about 8:30. As we drive down the slope of Mt. Carmel we have a grand view of the whole harbor of Haifa and of the industrial area built on a reclaimed swamp. Looking back on the footslopes from the plain, the soil appears to be Terra Rossa-Lithosol. The soil is now being planted to forest. Old springs along the footslopes testify to the water collection of cracked limestone. Formerly the great swampy areas along the river here led to much malaria.

The air is now hazy from the hot easterly winds. On the patches of upland the old oaks, formerly suppressed by Arab goats, are now growing into trees. At least part of these low uplands have Rendzina soil.

We go on east over undulating country with very dark brown soil, probably Rendzina-Alluvial. I see wheat, oats, weedy fallow, and some weedy sugar beets. I see some young maize.

We continue east over another low ridge and pass Ramatyishai. The cover includes olives, oak, and some

pine, with cereals and vegetables in the favored places. Then again we are on an undulating plain, mainly old and recent alluvium, with oats, fallow, barley, and weedy fallow. As elsewhere, essentially all field work is done with tractors. These do not get into the bad weed patches.

We approach another ridge but follow the margin of the plain to the southeast. Here, I see some vegetables with overhead irrigation. To my left (north) the soil is stony, lithosolic, Rendzina and Terra Rossa. The high terraces in the plain appear to be dark reddish-brown Terra Rossa.

I see here, in the uplands, a small flock of sheep -- one of the very few in Israel. Although formerly overgrazed by Arabs, the hilly land is now badly undergrazed. The busses stop for a moment, and I see that we shall leave the plain and go east into the hills. These have mainly lithosolic Terra Rossa with spots of transition to Rendzina. On the ridge the soil is thin but fairly deep for lithosolic Terra Rossa. There are olives and recently-planted trees. This soil could be used more intensively. Weeds are bad.

We see a large plain to the south and southeast -- the Plain of Esdraelon -- and the town of Affula in it.

We continue east over stony, lithosolic Terra Rossa, cleared only in the favored places. The Arabs had used this soil only

for grazing to recent centuries. Some parts are terraced and used for olives, vines, and fruits.

We came into Nazareth and stop long enough to visit the Church of the Annunciation. The first one was said to have been built 1400 years ago. It was three times destroyed. This was by the Franciscans. The place where Mary lived when Angel Gabriel told her back in the cave kitchen.



Nazareth is

sorts of Christian. K-2140 May 13, 1952
Esdraelon Plain.

We have light movements and leave shortly after lunch, going east into a big plain of dark reddish-brown, stony soil from alluvial. This is mostly irrigated from the margin of the Sea and the Jordan. The soil is used for round halos.

We are now on the Sea and the Jordan water at 200 meters



meters in the alluvial plain. The soils in the plain are made

K-2141 May 13, 1952
Nazareth.

for grazing in recent centuries. Some parts are terraced and used for olives, vines, and fruits.

We come into Nazareth and stop long enough to visit the Church of the Annunciation. The first one was said to have been built 1600 years ago. It was three times destroyed. This one -- the fourth -- was built in 1730 by Franciscans. The church is presumably built over the spot where Mary lived in a cave and where she was told by the Angel Gabriel that she would be the Mother of Christ. Further back in the cave one may see what is alleged to be Mary's kitchen.

Nazareth is a great mixture of Jews, Arabs, and various sorts of Christians.

We have light refreshments and leave shortly after 11:00, going east into a big plain of dark reddish-brown, clayey soil from alluvium. This is partly irrigated from wells at the margin of the low mountains (or high hills). Much of the soil is used for cereals. The straw here is baled in round bales.

We are now near the divide between the Mediterranean Sea and the Jordan River. It is said that one may find water at 200 meters in the hills but not at more than 400 meters in the alluvial plain. The soils in the plain resemble

the "tirs" of north Africa, which are related to gilgai. The soils here have imperfect drainage and are massive to coarsely prismatic. We pass Tel-Adashim; then Kafartavor.

The soils are undulating now and most have moderate to good drainage. They are dark reddish-brown. The material is said to be interbedded alluvium and thin basalt. Crops are cereals, olives, and some vegetables.

As we approach the Jordan Valley, the rocks are said to be tertiary and Pleistocene basalt ^{the} (of/rift). I'm told that the lowest place in this rift valley is 700 feet below sea level. To avoid high pumping costs, thought is being given to building a big reservoir, although there is danger of faulting in the upper part.

We have a gorgeous view of Lake Tiberias (= Sea of Galilee) and the valley south of it. The valley floor is closely occupied and I see many fish ponds. Now we go down steep slopes toward the floor of the valley. The stony, steeply-sloping lithosolic soils from basalt are all quite well covered with grass. The soil looks like Reddish-Brown Latosol, but this trip, like the others, has no stops included for examining the soils.

We pass Yavneel at about sea level, and continue downgrade to the east. I see some irrigated vegetables and pasture; cereals; olives; and some derelict land.



K-2143 May 13, 1952
Lower tip of Lake Tiberias.

I'm told that when the Jordan flows into Lake Tiberias (old Sea of Galilee) it has 20 ppm of chlorides, but 300 ppm when it leaves. Part of this salt comes from springs that it may be possible to control. Here are also some hot radioactive springs that may have therapeutic value (?)

We come down to the shores of Lake Tiberias and drive to the lower end. I see many fish ponds; irrigated vegetables; green fodder; fruits, including bananas and apricots; vines; and olives. This is a beautiful rift valley with a basaltic base and plateaux. The base is covered with recent deposits. The lowlands are said to be naturally salty and have been improved only recently, through irrigation and drainage.

We stop for lunch at Beityerah in a cultural center built by the general federation of labor.

We have a talk by an old settler-technologist, by name Stoler -- a leader in this community for 33 years. This is translated from the Hebrew. He makes the following points:

Most agricultural land in this area is operated by kibbutzim. The rainfall is roughly 470 mm (18 inches), all in winter. The earliest Jewish settlers of 50 years ago found here a sparse population of poor Arabs who got occasional crops of wheat. Now farming is becoming intensive with an average of 6 acres per family. Crops include: bananas, tomatoes,

dates, potatoes, alfalfa, grapes, and olives. They have Freisian cattle. Some kibbutzim delegate certain of their members to look into the problem of new crops and new cultural methods. The various ideas are discussed here at the cultural center. They are now making a special study of the banana. (The speaker exhibited chlorotic banana leaves and healthy ones produced with ferrous sulphate spray.) He says only 30 percent of the soil water between field capacity and the wilting coefficient is used by bananas.

Now that so much water is being used for irrigation, drainage is becoming an increasing problem. They are now studying proper crop rotations for banana. They don't like them for more than four years continuously in one place.

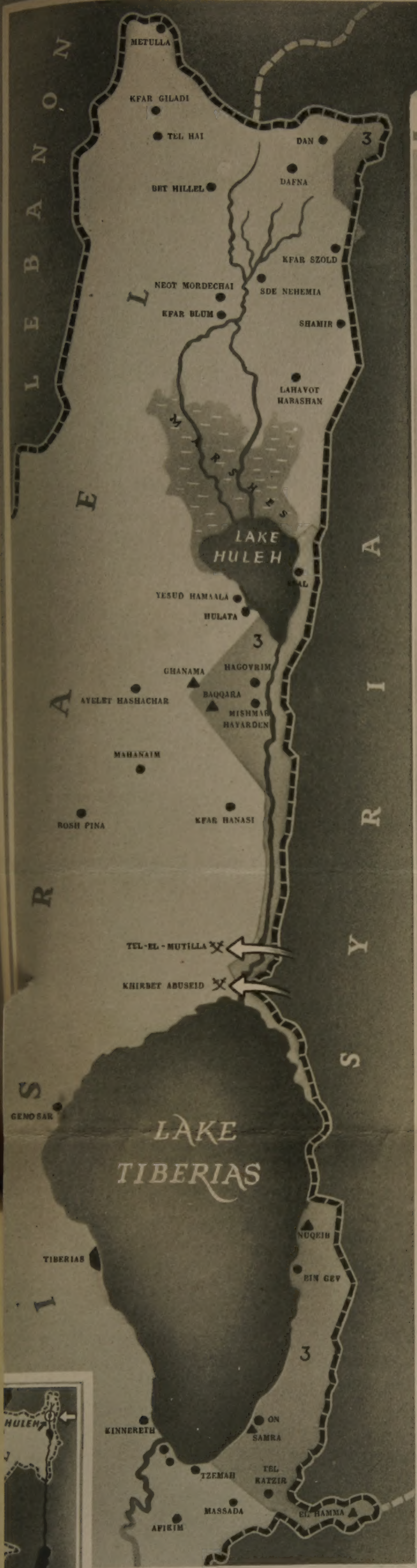
Several of us ask to see the bananas, so after lunch we take a short trip south, over the Jordan River, onto an area of dark gray clayey gilgai-Alluvial soil high in lime. The structure is mixed blocky and granular and looks to me as if it could easily get to be massive with bad tillage. It is a pity our time is so short here. (We waste too much in listening to detailed statements of "schemes.") The bananas are harvested in September and March. Windbreaks are necessary. These are partly cane and partly old banana plants not used for fruit. Each plant here has $7\frac{1}{2}$ square meters and needs 8 to 10 mm of water per day. At first, the



K-2144 May 13, 1952
Near Tsemah. Bananas on dark gray gilgai-
Alluvial soil.



K-21145 May 13, 1952
Near Tsemak. Mr. Stoler, a community leader by a banana with off-season fruit.



LEGEND

- 1 Over-saturated soil
- 2 Peat deposits within the marshes
- 3 Demilitarized zone
- Rivers
- Roads
- Main drainage canals
- Subsidiary drainage canals
- Boundary of Israel
- Other boundaries
- Jewish villages
- Arab villages
- Scenes of fighting



bananas were underirrigated. Never have I seen bananas pruned so severely as in Israel. These here are not pruned so much as some.

We pass two very nice date gardens on the way back north. But no time! North of our lunch stop to Tiberias, the coastal strip is narrow. I see just a few sheep. Too few. This is a hot place despite the lake. I see a few fairly large eucalyptus trees.

North of Tiberias the road is further from the lake and we cross a small irrigated alluvial area used for vegetables. Part is almost swamp. I see more bananas, severely pruned to one small leaf. As we go north we pass over a fairly wide strip of this Alluvial soil, much of which is used for unirrigated cereal. The basaltic hills are dry and grass covered with only a few small shrubs. Here I see loose boulders in only the steepest places.

Then the road takes us up into the hills. There is some cultivated soil on the lower, easy slopes. As we go along -- roughly opposite the north end of the lake -- I see many loose boulders on the hill slopes.

We again go above sea level. Here is a large area of hilly basaltic Lithosol, very stony and bouldery. There are no trees and but few shrubs. There is much grass and weeds going to waste. The country looks hot and desolate.

We pass on to undulating country of limestone and basalt with soils in the Rendzina-Terra Rossa transition. Bulldozers and rippers are used to remove the large stones and prepare the soil for cultivation. It is a great pity that more of the hilly soil is not used for grazing. Such a waste! The alternative for overgrazing by Arab goats should not be such wasteful undergrazing. With moderate grazing, the cover would be even more protecting. As we go along, the proportion of Terra Rossa increases.

We stop a moment in Rosh-Pinna. We soon drive north over beautiful undulating Terra Rossa with few stones. I see cereals, sunflowers, and potatoes; but only a few olives. The bold hills to the west and southwest are probably an extension of those seen before lunch.

After a little way we pass over a mile or so of lithosolic Rendzina and then back into Terra Rossa. The non-stony, dark reddish-brown clayey soil is probably from mixed basalt and hard limestone in old terraces.

We pass west of the papyrus swamps around Lake Hula. I'm told there is a scheme to drain this whole area. Enormous amounts of water are lost by evaporation and transpiration from the swamps. The road here follows rather low, but well-drained terraces. The soils are used for cereals and irrigated vegetables.

Far to the northeast I can see Mt. Herman in Syria. It has a bit of snow left on it.

Soon we turn west into bold hills. The thin soil cover nearly vanishes. The rocks appear to be conglomerate and limestone.

As we reach the plateau the bus engine is very hot. A very long stop is taken here for exceedingly detailed explanations (which everyone will immediately forget) on grand schemes for irrigation, water storage, and drainage. Most of this time could have been spent more fruitfully in looking at the soils. Here, on this hill crest, one sees only lithosolic Terra Rossa, old Arab buildings, and distant views of the swamps around Lake Hula.

Finally we are back in the busses and go west and south over a military road built by the British under the Mandate. It is just a few yards within Israel from the Lebanon frontier. Almost at once we cross a small, nearly flat alluvial plain with very dark reddish-brown soil growing nice alfalfa. Then we go into the stony hills again. Weeds are very bad along the road. This hill land ties onto the large area further south that could be used for grazing but is now derelict.

As we get farther up on the plateau, the rolling stony Terra Rossa is being reclaimed for cereals. Stones are being

removed and talus was deposited. The slope and the quality of the soil is very different on the Lebanese side. But there is good work, too, on the Israeli side. The Lebanese farmers use very simple and hard work while the Israelis use very rough modern results.

On the Israeli side the land is overgrazed with goats grazing on one side and on the other.



K-21146 May 13, 1952
Northwest of Lake Hula. View from high margin of the rift with Lake Hula and the swamps in middle background.

The border, some of the vegetation is soft and I see some traditional rather than some modern. Near Lake Hula I see a fairly large number

of figs as they are suffering from drought. Some of the people are working. It seems to be a very good work - it is a very



K-21147 May 13, 1952
West of Lake Hula. Characteristic Terra Rossa landscape.

removed and terraces constructed. The crops and the quality of farming look better on the Lebanon side. But there is good work, too, on the Israel side. The Lebanese farmers are using donkeys and hand work while the Israelites use mainly machines. The road here is very rough indeed. I try for pictures but fear the results.

On the Lebanon side, the upper steep slopes are overgrazed with goats. Thus, we have wasteful overgrazing on one side of the road and wasteful undergrazing on the other. The Lebanese farmers have certainly done well with cereals in strips on the lower, easy slopes. Where the road turns south from the border, some of the limestone is soft and I see Rendzina-Lithosol rather than Terra Rossa-Lithosol.

Near Kefar Bir'am I see a fairly large planting of figs on stony, hilly Terra Rossa. These trees are suffering now from competition with weeds and wild grasses. Some olive plantings have the same handicap. These people must learn that machines cannot do everything. It takes a lot of hard work -- and some hand work -- to farm this kind of soil successfully.

As we start on the road to Mcharife, we pass a kibbutz with a dairy herd, olives, fruit, and some new plantings of vines.

All along here we see many old abandoned terraces in the derelict, wooded grazing land. Then we go west into steep, rugged

We pass a village in Syria. They have olives, tobacco, the Druze village is very short and



Jew, or Arab. These are the old terraces in the Northeast Shefer. Looking north at Lebanese farming of Terra Rossa. Stones moved by hand. Most of the old terraces are on the slopes. They are controlled by the fields and orchards. They have goats, but no sheep.

I could have a sheep

About 1/3 of

toward Ram. The

Rossa used by a

another good village

mixed, only north



the non-Jewish

K-2148 May 13, 1952
Northeast Shefer. Looking north at Lebanese farming of Terra Rossa. Stones moved by hand.

K-2149 May 13, 1952
Hurfeish. Farming on Terra Rossa.

As we start on the road to Nahariya, we pass a kibbutz with a dairy herd, olives, fruit, and some new plantings of vines.

All along here one sees many old abandoned terraces in the derelict, unused grazing land. Then we go west into steep, rugged Terra Rossa.

We pass a village of Druz people, who migrated from Syria. They have beautifully-terraced fields of cereal, olives, tobacco, and fruit on the Terra Rossa. We pass the Druz village of Hurfeish. I try pictures, but time is very short and the light poor.

These folks have their own religion -- not Christian, Jew, or Arab. The women have more freedom than in Arab communities. They certainly know how to farm Terra Rossa. Most of the plantings are on the contour. Weeds are controlled in the fields and orchards. They have goats, but no serious overgrazing is to be seen. I wish I could have a day for this beautiful village.

About 1/3 of the way to the sea, we turn south toward Rama. We pass a nice area of reclaimed Terra Rossa used by a cooperative village. Then we pass another good village -- Pequn (?). It is said to be mixed, only partly Jewish. (I'm not clear whether all the non-Jewish are Arab or not.) Here is a very good



K Is. 8.5 May 13, 1952
Hurfeish. Well terraced Rossa (Druz people).

K Is. 8.5 May 13, 1952
North of Haifa. View looking from highlands of Upper Galilee
into Lower Galilee. Mostly Druz Rossa with olives, fruit, etc.

job of terracing the Terra Rossa, even when steep and stony. I saw tobacco, olives, vineyards, etc. They also have sheep and goats for the poorer part of the hill pasture.

As we pass from Upper Galilee to Lower Galilee we go along the side of a steep slope. (The houses are for the most part built on the hillside.)



K Is. 8.6 May 13, 1952

North of Rama. View looking from highlands of Upper Galilee into Lower Galilee. Mostly Terra Rossa with olives, fruit, etc.

The whole of the heavy clay traffic.

We reach the hotel at 5:45 p.m. Since this has been a hot day, cold water has been used. The hotel is on a mountain and my room is on the third floor. So no water! I can reach a bath on the first floor and then go to dinner. I found the next I left on the

job of terracing the Terra Rossa, even where steep and stony. I see tobacco, olives, cereals, and fruit. They also have sheep and goats for the proper use of the hill pasture.

As we pass from Upper Galilee to Lower Galilee we go along the side of a steep slope. (The busses stop for unnecessary and uninteresting lectures about what is obvious.) Then we pass Rama and turn west. The road passes through a narrow and beautiful valley of Terra Rossa from the alluvium of the hard limestone. The terraces are very gently undulating. I see very nice olive plantings and many other crops.

It is most too dark to write and we are a very long way from Haifa. My back is very sore now. As we come near the sea, the valley widens out into a broad plain.

We pass Acre and go south over the sandy coastal plain to Haifa. It becomes dark and we must pass through the whole of the heavy city traffic.

We reach the hotel at 8:45 p.m. Since this has been a hot day, much water has been used. The hotel is on a mountain and my room is on the third floor. So no water! I can wash a bit on the first floor and then go to dinner. I found the suit I left on the

bed to be pressed (as instructed) simply hung back in my closet. I'm afraid the manager regards me as a hard-to-please American. Anyway, he promises it by 8:00 a.m. tomorrow morning. Never in two days have I drunk so much water, orange juice, and the like as during these last two.

Rarely have I seen greater contrasts in soil use along a border as today. The Druz people certainly know how to handle Terra Rossa. Perhaps their labor income is low; but the village, the people, and the crops looked good. Above all, they know better than Jewish farmers the importance of keeping down weeds, especially during the dry season. Also they know how to use the hill land for grazing sheep and goats without harm.

The Lebanese overgraze; the Jews undergraze; and the Druz seem to do it properly. But in the mixed village -- Jews and Arabs -- the farming is also good. I saw beautiful groves of very old olives.

My driver refused a tip. Since the busses are owned cooperatively by the drivers, he considers himself more owner than driver. He is the most skillful bus driver I ever saw.

To bed, exceedingly tired.

May 14

This promises to be a warm day. Fortunately, there is a little wind from the east, but also unfortunately there is little from the west off the Mediterranean. I go down to the reception room and read a while before breakfast. I get my suit as promised, and after breakfast go by bus to the Hebrew Institute of Technology for the final day of the Symposium. The program begins at 9:15.

Dr. Danel of France gives the first paper, The measurement of underground water distribution. He emphasizes that as liquids flow through porous media, there is an important mixing action. (I should say this must be local in soils.) For water moving down through a fine sand filter, he speaks of an angle of diffusion of about six degrees. He emphasizes the great importance of differences in density of the horizontal layers of water in a porous medium such as alluvium. If an upper layer is heavier than the lower layer, because of salt for example, there is much mixing; if the heavy layer is beneath, however, there is little mixing. Mixing also depends upon the topography of the interface. Thus, with sudden changes in pressure, mixing is increased.

By drawings he illustrates the pattern of equal concentration developed by the addition of a dye, let us say, in the water added at the surface. By measuring the dye or another added material, one may calculate water movements through porous media for long distances. He apparently rejects the theoretical flow paths determined by electrical field analogs.

The next paper is by Dr. L. A. Richards of the United States on Water conducting and retaining properties of soils in relation to irrigation. In this paper Dr. Richards reviews the more significant work at the Salinity Laboratory.

A paper by R. L. Boke of the United States was read for him; The application of hydrologic technique to ground water problems in California's Central Valley.

This meeting is held in a student lecture room with the worst seats I have ever seen, excepting those in the University College of North Wales.

Dr. M. G. Drouhin of Algiers gives a long paper entitled Aspects divers de l'hydrologie in region desertique. Although this is an excellent paper given by a man of broad experience, he speaks so rapidly in French that I understand but little of what he says. I am glad to

hear him stress grazing and he points out that it is often better to use water for grazing sheep and cattle than to attempt irrigation.

The sessions run overtime partly because so many want to speak. Several of the local people attending the conference use the device of a question presumably directed at the speaker to make a comment. Often these comments turn out to be long speeches, only tangentially related to the speaker's subject, if at all. And most of them get away with it!

I go back to the hotel for lunch. I learn that I am to leave for the Lydda Airport by taxi at 3:00 p.m. tomorrow. This means a wait of at least eight hours at the station. But I am assured of a room there.

I go back to the session at 3:00 p.m.

The first paper, read by Dhir of India, Inter-relation of surface and ground water with special reference to arid zones, is not very interesting.

Professor Picard of Israel talks on Prospecting for underground water in Israel. Obviously the speaker has enormous confidence in his judgment. He takes many times too many words and much overemphasis to explain that water was found when they drilled deeply in the hard limestone, especially in dolomitic limestone. He mentions the structural

basins in the mountain footslopes to the south and the fault collectors in the north.

Mr. E. W. Golding of the United Kingdom gives a very interesting paper on the Utilization of wind power. He shows pictures of installations in northern Britain and in Denmark. I didn't realize that these developments were so far advanced.

At the close of this session we go to a reception in the town hall. Because of the long days during the field trip my back is beginning to give out, but a few aspirin tablets restore me. At the reception I have an interesting conversation most of the time with Mr. and Mrs. Goldstein. He is president of the Hebrew Institute of Technology here in Haifa.

After the reception we are back for the final session at 8 o'clock. This includes a few pretty speeches but the main event is a summary statement by Sir Ben Lockspeiser. He does a most excellent job.

Some resolutions to UNESCO are put forward for brief discussion. Most of these are all right. Aubert and I object to one resolution asking UNESCO to prepare a handbook on basic data for arid regions. I suggested that one cannot get all of such relevant material into

one handbook, and that such handbooks would be accepted only if prepared by recognized specialists. UNESCO could encourage scientists to prepare them.

There is a good deal of discussion about various details, international societies and means for advancing research in desert regions. I am asked to suggest any points of special significance that have occurred to me during my visit in Israel. The time is very short.

Added later: At the request of Dr. Sambursky I outlined these later and gave them to him. A copy follows:

"1. I gained a definite impression that a good start is being made in soil research. I had a favorable impression of the work begun at Rehovot. There is great need for further soil survey work in Israel to guide the land development schemes and especially to make full use of the research information already available in Mediterranean countries and that will be coming from your own researches. I should like to urge with all emphasis that this soil survey work be coordinated in a single agency as a part of the agricultural experiment station. Otherwise, a lot of money may be spent on rather "simple" or "short-cut" surveys that will have only very limited usefulness. I think that a mature American soil scientist with long experience

in our National Cooperative Soil Survey could possibly be of some assistance if he could remain a few months with the experiment station.

2. I see a great need for careful budget analyses of representative farms in different parts of the country and with different organizations -- individual farms, cooperative farms, and kibbutzim. Techniques are fairly well advanced for doing this kind of work, especially under Dr. John D. Black of Harvard University. The results would indicate the relative economy of different systems and the potentialities for their improvement in the present state of our knowledge of agriculture.

3. I was greatly impressed with the under-grazing in Israel. I realize that a great many of the Arabs have overgrazed the land with sheep and goats. The results have been excessive runoff, soil erosion, and depleted pastures. But the cure for this is not extreme under-grazing, which is wasteful. As a matter of fact, we might expect somewhat better protection of the soils with moderate grazing than with no grazing at all. I was particularly impressed with the under-grazing in the northern part of the country where sheep and goats could be grazed to great advantage with proper controls

to prevent overgrazing. I see also considerable possibilities for sheep farming in some of the semi-desert area of the Negev. I think you should be cautious about pushing agriculture too far toward the desert. After all, you will be settling people of European culture who must have a reasonably good standard of living to be satisfied. Some wells can be developed as water spreaders to conserve the moisture for grazing. The more favored locations may be greatly improved through seeding to better grasses.

4. One of the biggest practical problems I saw in Israel was the matter of the weeds. Much more effort must be put on their control. I think a part of this comes about by the desire of your new farmers to use machinery. But farming in hill countries requires some hand work, including the cutting of weeds or their eradication by chemicals. Yields of sugar beets, citrus, vegetables, and other crops are certainly being unnecessarily reduced by competition with weeds. Many of the roadsides and odd corners are filled with weeds and furnish weed seeds to the arable land.

I noticed in one of the reports that the grass Imperata cylindrica is being used for stabilizing sandy soils against the wind. It should be emphasized that this grass is probably the greatest single enemy of

agriculture in tropical countries. It can become an exceedingly serious pest. I doubt that I should use it for any purpose. Certainly if I did I should watch it most carefully and not let it get near any farm land.

5. I should probably emphasize again the matter of too excessive reliance upon mechanization. I am sure that some hand work and perhaps some work with animals will be necessary for good farming in parts of the country.

6. I hope your fertilizer industry will soon be able to produce high analysis nitrogen and phosphatic fertilizers. Traditionally, many farmers are accustomed to ammonium sulphate and nitro-chalk. These are low analysis materials and are no longer necessary. Further, the manufacture of ammonium sulphate requires sulphur, of which your country is short and which few, if any, of your soils require. I hope that you can soon be producing urea as a nitrogen fertilizer, or ammonium nitrate, the high analysis superphosphate, and di-ammonium phosphate.

After the session, which winds up the Symposium, I go to the Goldsteins for late tea and then back to my hotel.

May 15

I am up at 5:00 a.m. to say goodbye to Aubert. He is leaving early for Jerusalem in order to have a day in the old city in Trans Jordan.

After breakfast Mr. Goldstein (a different one) takes Professor and Mrs. Leighly and me for a drive up the coast to the old fortified city of Acre. South of the town, sand is being deposited on the beaches and blown inland. This dune area is just partly stabilized. Acre is a fortified city with a long history. I am told that Napoleon was unable to take it even though he had good siege guns. The walls are exceedingly thick. There are a few indentations for entrances, but the gates are on the margins of these indentations and cannot be flanked.

The streets are narrow and rough with little shops crowded with people. I think most of the women on the street are probably Jewish from adjoining areas. Certainly the town suggests many in North Africa. I even see a few negroes.

I go into the mosque -- a comparatively recent one built only 275 years ago. I take off my shoes and go inside for a few minutes. How I should like my choice among the prayer rugs!



K-2150 May 15, 1952
View of Acre.



K-2151 May 15, 1952
Near Acre. Sand dunes.

I walk around the streets a bit and get a few pictures. After returning to Hotel I do a little shopping and then go to my hotel for lunch.

After walking, I have time for a very short nap

before the car

we were with us

in the hottest

station and

The car is

to Tel-Aviv

and no more

actually

large

in tests.

I get to the airport about 5:30, and

have dinner. I

at 11:30, with

1950 in the

at 11:30 to find

I go back to my

sleep. This, too



K-2152 May 15, 1952

Near Acre. Beginning of stabilization of dune sand.



K-2153 May 15, 1952

Near Acre. Beginning of stabilization of dune.

I walk around the streets a bit and get a few pictures. After returning to Haifa I do a little shopping and then go to my hotel for lunch.

After packing, I have time for a very short nap before the car calls to take me to Lydda. I had thought we were well on our way, but our driver parks the car in the hottest part of Haifa in front of a railway station and waits for 1/2 hour.

The car is full. We drive through heavy traffic to Tel-Aviv with either one or two cylinders missing and no words said. I wonder whether or not we will actually reach the airport. Near Tel-Aviv we pass a large transition camp for immigrants who are living in tents.

I get to the airport about 5:30, rest a bit, and have dinner. I am told to check in for the flight at 11:30, although it isn't scheduled to leave until 1:00 in the morning. After a short nap I come down at 11:30 to find the plane won't go until 3:00 a.m. I go back to my room and there is too much noise to sleep. Thus, this day ends.

We are in the air at 12:32. We go west over Italy and pass almost directly over Florence, headed straight for Zurich. I have one complaint for lack of comfort:

May 16

About 1:45 I am told to be ready with my passport, money, and baggage. Now at 2:20 I am waiting -- and I expect I will be waiting for some time. Finally we are in the plane at 3:35, crowded like sardines and with a very indifferent stewardess. The captain waits for the fog to lift, but it doesn't. We sit and wait at the end of the runway. Then at 5:00 a.m. I get off the plane to have breakfast!

At 7:20 a.m. we are back in the plane since the fog has lifted. It is a great pity that one of the very rare fogs of Lydda had to be here this morning.

We are away at 7:40 in this crowded plane.

At 11:08 we are down at Athens for a badly served lunch. Is my temper stretched too much?

We are back in the plane at 12:15. I have a seat now where I can see out of the window, but it is very uncomfortable. So many extra seats have been put in that one with long legs is badly cramped. Suitcases are piled high on the racks above. If we have any bumpy going, a lot of people are bound to get hurt.

We are in the air at 12:32. We go west over Italy and pass almost directly over Florence, headed straight for Zurich. I have one compensation for lack of comfort:

we go over the Alps without clouds! Our pilot has a little trouble getting down at Zurich, but we are finally there at 5:25, which is 3:25 local time.

We take a long time at Zurich for tea and waiting, and then go on to Paris at 5:15. At 6:45 we are down in Paris for a nice supper, which is very slowly served. At 8:20 we are again in the air. At 9:30 our wheels are on the London Airport. Then customs, a wire home, and a long ride to Victoria Station. Fortunately, Brigadier Bagnold is with me and suggests that we may get a room in a hotel nearby, the Grosvenor, and finally to bed a little before midnight very, very, tired indeed.

May 17 (Sunday)

I feel much better this morning but not back to normal. I hurry through breakfast and then go to the hotel hairdresser. I take a cab up to the shopping center, get some money at the bank, and buy some articles at Liberty's to send home. I return to the hotel, pack, and get the 12:05 train for Harpenden.

I arrive at Muir's about 1:00, just in time to have lunch with them and with Dr. W. H. T. Williamson, Reader in Soil Science, Aberdeen University. We spend the afternoon exchanging experiences in various parts of the world.

Dr. Muir has a schedule nearly worked out for my brief stay in Britain, to be finished with telegrams and telephone calls for Monday.

The Crowthers come in during the evening for coffee and we have a very pleasant chat.

May 18 (Sunday)

Most of today I rest and talk with Dr. Muir. I have quite a problem to quiet down my stomach following the fatigue of the last several days.

I go with the Muirs for afternoon tea with Dr. and Mrs. Crowther.

I bought a special garden

tool for making holes in the lawn. At Rothamsted I saw Dr. Guy Smith, Mr. Demand, Dr. Greene, Mr. Jenks, and the others.

Sandy and I go to lunch with the Gys. After lunch I talk with Mr. Wilkin for two or three hours in his garden about plans and projects for various kinds of agricultural work in our two countries and in Africa.

I take food in the evening and pack up for the journey to Oxford tomorrow with some belongings.

May 19

I am up early after a good long rest. Sandy calls his physician and gets the promise of medicine for my sick stomach. He also tells me to starve myself for the next few days.

On the way to Rothamsted I buy a special garden tool for making holes in the lawn.

At Rothamsted I see Dr. Guy Smith, Dr. Osmond, Dr. Greene, Mr. Jacks, and the others.

Sandy and I go to lunch with the Oggs. After lunch I talk with Sir William for two or three hours in his garden about plans and projects for various kinds of agricultural work in our two countries and in Africa.

I skip food in the evening and pack up for the journey to Oxford tomorrow with some misgivings.

May 20

I am up early and leave Harpenden on the 8 o'clock train for London. I go over to the American Express and buy tickets for Oxford and Aberdeen and get the 10:45 train for Reading.

I reach Reading a little before lunch. A driver takes me out to the National Institute for Research in Dairying. On the way I pass the old jail where Oscar Wilde wrote his famous Ballad of Reading Gaol.

It is very good to see Dr. Kay again, with whom I had such pleasant excursions in New Zealand. We have a conversation during which he explains their main research program. Then we go to lunch at the station with members of the staff. Afterwards I take a quick look at the several branches of work -- biological chemistry, especially endocrinology, engineering, and physics. We take a short tour to look at the cattle and some of the field management work. I see, for example, some interesting field plots comparing mixed clover and rye grass with rye grass fertilized with nitrogen. Clover is kept out of the grass plots with hormone weed killers.

I am deeply impressed with the excellent work going on in this institute, which clearly reflects Kay's high intelligence and far vision.

In the afternoon I have tea chez Kay. I have a short tour of the garden with Mrs. Kay but the rain drives us in.

Dr. Kay puts me on the train for Oxford at 4:48 p.m. with one minute to spare. I don't know whether it is the medicine or the starvation, but my stomach is improving.

I am met by Dr. E. Walter Russell at 5:50 and we go to his home. I still decide to go without food. We have a long interesting discussion during the evening about several fields of soil science, with special reference to the needs in Africa and other tropical areas. It is a pity that Dr. Russell doesn't have more facilities and assistants for the training of people to undertake the researches that are so necessary if Africa is to develop. Lack of soil surveys is especially critical. He explains to me some of the problems of coffee, rubber, sisal, and other tropical crops as he sees them.

To bed just before midnight.

I am on the train at 9:30 and leave for Aberdeen at 10:15.

May 21

We continue our discussions in the morning and then go to Blackwell's famous book store for a little while where I buy some books to send home. In the late morning we drive out north to Campsfield Wood, near Woodstock, to see Sir John and Lady Russell. Though Sir John is not strong physically, he is well able to get around and his mind is keen and alert. He is now in the midst of a book on the agricultural potentialities of the world as he sees them. We discuss some of these points and then Walter and I return to his house for lunch.

After lunch I spend some time with Dr. Russell in his laboratory at the University. Then we go to have tea with Professor Prescott of Australia, who arrived just a day or two ago. After an hour or so of chit-chat I return to the Russells' for a very light supper and to pack. Walter puts me on the London train at 7:35 p.m. This day has been bright and sunny, but quite cool.

I arrive at the station at 9:05 and taxi over to King's Cross. I am on the train at 9:30 and leave for Aberdeen at 10:15.

May 22

I arrive in Edinburgh at 6:30 a.m. This gives me nearly an hour to walk out on the famous Princess Street. Although a little hazy, it is a bright warm sunny morning. After a short walk and attempts at pictures, I am back in the train and we leave Edinburgh at 7:30.

Since my stomach is much better, I have a proper breakfast on the train. I try many pictures and wonder how they will turn out.

I am met at Aberdeen just before noon by Dr. A. B. Stewart. I get settled in my room at his house, do a little shopping, have lunch, and then go out to the Macaulay Institute for Soil Research.

Dr. Stewart shows me his tentative program for his coming visit to the United States this summer. We discuss it in detail and I make a few minor suggestions. We call on the director, Mr. McArthur, and each of the principal departments of the institute where I am given short reviews of their research program. Mitchell tells me that they have had good results with soil tests for cobalt by extraction with acetic acid at pH 2.5. They have around 70 to 80 percent correlation. They determine the cobalt on the extract with a spectrograph. He finds the results more reliable than those obtained by plant analyses.

We go back to Stewart's home for dinner and a little chit-chat.

May 22

I arrive in Edinburgh at 6:30 a.m. This gives me nearly an hour to walk out on the famous Princess Street. Although a little hazy, it is a bright sunny morning. After a short walk and attempts at pictures, I am back in the train and we leave Edinburgh at 7:30.

Since my stomach is much better, I have a proper breakfast on the train. I try many pictures and wonder how they will turn out.

I am met at Aberdeen just before noon by Dr. A. S. Stewart. I get settled in my room at his house, do a little shopping, have lunch, and then go out to the Macaulay Institute for Soil Research.

Dr. Stewart shows me his tentative program for his coming visit to the United States this summer. We discuss it in detail and I make a few minor suggestions. We call on the director, Mr. McArthur, and each of the principal departments of the institute where I am given short reviews of their research program. Mitchell tells me that they have had good results with soil tests for cobalt by extraction with acetic acid at pH 2.5. They have around 70 to 80 percent correlation. They determine the cobalt on the extract with a spectrophotograph. He finds the results more reliable than those obtained by plant analyses.

We go back to Stewart's home for dinner and a little chat.



K-2154 May 22, 1952
Edinburgh. Princess Street.



K-2155 May 22, 1952
Edinburgh. Princess Street.



K-2156 May 22, 1952
View from train between Edinburgh and
Aberdeen.



K-2157 May 22, 1952
View from train between Edinburgh and
Aberdeen.



K-2158 May 22, 1952
View from train between Edinburgh
and Aberdeen.



K-2159 May 22, 1952
View from train between Edinburgh
and Aberdeen.

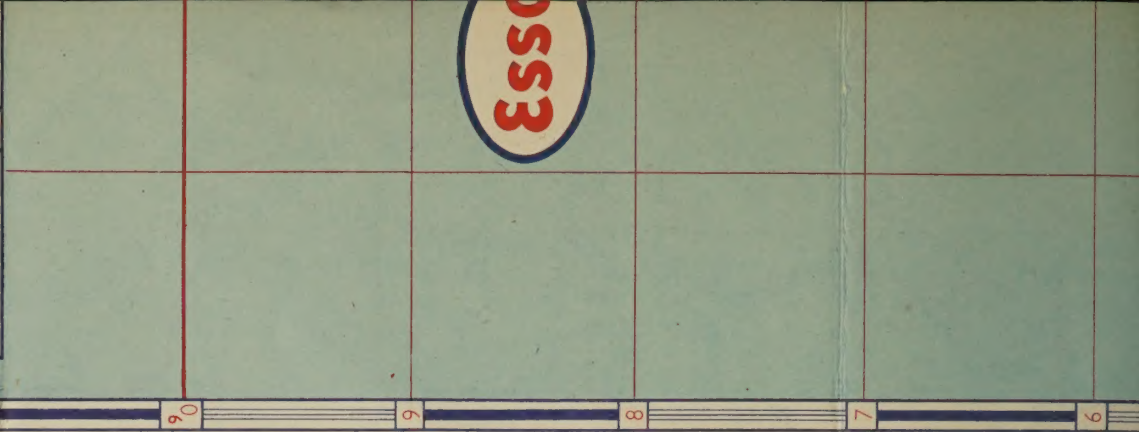


K-2160 May 22, 1952
On train south of Aberdeen.



K-2161 May 22, 1952
On train south of Aberdeen.





ESSO ROAD MAPS

to say

SSO

May 23

Although I slept well, I get up with a sore back in a gray, cold morning. After breakfast Stewart and I go out to the Macaulay Institute. There I meet Dr. R. Glentworth and we organize for a day in the field. Several make up the party: Grant, Laing, Romans, Mulcahy, Coulter (Malaya), Moss (Nigeria), J. Muir, and B. Mitchell. We start in a clear sunny day, only a bit cool now, at 9:55 a.m.

We take the South Dee-side road, southwest of Aberdeen. The soils look to be Brown Podzolic or Brown Forest from alluvium and glacial drift. Stone fences surround medium-sized fields of turnips, oats, and grass mainly.

We first stop in the Tilbouries Wood about eight miles west of Aberdeen. The cover is mainly hazel, birch and mucralesus. The soil is moderately well drained with slopes of four to eight percent. The original till may have been somewhat reworked by water. There are some stones. This area of soil is thought to be virgin. The mull has a pH of about 6.0. Normally in this section, forested soils have a raw humus rather than mull.

- | | |
|---------------------|--|
| A ₀ | Very thin mull and moss. |
| A ₁ 0-6" | Dark reddish-brown (5YR 3/3) heavy granular loam. Roots are concentrated here. |
| B 6-24" | Yellowish-red (5YR 4/6) gritty sandy loam. Some faint, coarse mottling with shades. Some stones. The soil is nearly loose. A "transitional" B. |



K-2162 May 23, 1952
8 miles southwest of Aberdeen. View
along the Dee.



K-2163 May 23, 1952
10 miles west of Aberdeen.
Profile of long-cultivated
Podzol.

C 24-36" / Brown (7.5YR 4/4) slightly compact fine sandy loam. Roots penetrate. Very faintly and coarsely mottled. Stones are very slightly rounded.

It is said that the till may have some limestone influence. I see no evidence for it.

Nearby we look at a long-cultivated Podzol on gravelly sand developed on a long slope. The profile is made on the margin of an old gully, now nearly stabilized with gorse. The soil is placed as the well-drained member of the Corly association.

A_p 0-10" Brownish-gray light sandy loam. Nearly loose.

B₂ 10-34" Banded, irregular, dark reddish-brown sandy ortstein.

C 34-40" / Yellowish-red loamy sandy.

As we drive along, I see a natural graft of a large branch of one scotch pine tree with the trunk of another tree a few feet away in the Birse Forest.

We drive on west. We stop for a moment to look at a heather Podzol -- with A₀ and A₁ some three to four inches thick, weak A₂, and a brown B without ortstein -- from acidic gravelly sand. The soil is thought to be over 100 years old.

A bit farther on we stop for a few moments at an old rural factory where wooden barrels and tubs are made,



K-2164 May 23, 1952
Southwest of Aberdeen in Birsø Forest. Natural graft of Scotch pine.



K-2165 May 23, 1952
Southwest of Aberdeen. Waterwheel used
in tub factory.



K-2166 May 23, 1952
Near Ballochan. Rural view, mainly heather
Podzol.



K-2167 May 23, 1952
Near Balloch. Heather Podzol on the hills.

using water power from an old wheel. The present owner-operator doesn't know how old the little factory was when his grandfather started to use it many years ago.

We then drive west, beyond Banchory, into the hills of lithosolic heather Podzol. I look at a heather Podzol with a disturbed peaty surface. The B is dark reddish-brown. Beneath it is a yellowish-brown and yellowish-red fragipan. In relation to soils I've seen in Holland and Eire, there is less evidence of gleying than I should have expected.

We follow up a beautiful little valley in the Forest of Birse, nearly to Ballochran. The lower terraces are cropped and the lower slopes used for sheep pasture. The higher parts are peaty.

We drive back to Feughside Inn, southwest of Banchory, for lunch.

In much of this valley forests have been planted, mainly scotch pine. The harvest is mostly with clean cutting followed by replanting. Natural reproduction cannot be depended upon. In the heather Podzol, small seedlings get about two ounces of superphosphate when set out.

After lunch we go south. I look hastily at several profiles of heather Podzol. As we go on into mountains we may expect slightly-gleyed soils and finally climatic moors in the highest parts.

I look at a peaty gley heather Podzol near Cairn O Mounth.

A₁ 0-16" Black greasy organic-rich silt loam.

G 16-20" Brown to pale brown, mottled with shades, sticky, heavy sandy loam. Light gray when dry.

D 20-21" Reddish-brown ironstone, compact but friable.

C 21-24"/ Yellowish-red sandy loam.

This hilly soil has a nearly solid cover of heather.

There is grass between the heather plants and odd spots with little heather. At the next step up in elevation are peaty Podzols. I notice that most of the soils here show stratification in slopes and local wash. I am told that this soil varies in pH, 3.5 to 4.0; and that the base saturation goes from 12 percent in the A to 5 percent in the lower solum.

I try a kodachrome of grazing sheep, which I hope very much will be good (Added later: a miracle happened; it is good.)

I look at other profiles that are essentially in the same series with this last one. Most of the soils have a marked microrelief due to slips, past frost action, and differential erosion following slips.

We go on up in the hills and I look at a peaty Podzol with some 18 to 20 inches of black well-decomposed peat over gley. This is underlain by a thin reddish-brown



K-2168 May 23, 1952
Glendye. Profile of heather Podzol with fragipan.

Grade: 100% of material tested with 100% pass
R-5108 Nov 53, 1955

KL168

hard ironstone that is characteristic of many Podzols in Britain. These layers are sheets, commonly $1/8$ to $1/4$ inch in thickness, and hard as any rock. Although common in Britain, I have never seen them in North America. This is underlain in turn with a compact yellowish-red material mottled with brown.

Some of the hill peat is quite deep. It appears to have gulleys in it; yet these are not primarily erosion channels. I think most of them originated as slips. Perhaps the principal moving force is frost.

We go south over and beyond the hills into a smooth area of soil from glacial till dominated by red sandstone. The sandstone is not particularly sandy. Some of the local soil types are very clayey indeed. I am told that the rotation here is oats, potatoes, turnips, and grass for one or two years. In contrast, near Aberdeen, the rotation is more usually three years of grass, lay oats, turnips, oats, and sown grass.

We come down onto a beautiful area of this undulating red soil, said to be the Lawrence Kirk association. Although moderately well drained, most of the arable soil has been tile drained.



K-2169 May 23, 1952
Glendye. View on heather Podzol with
25 or 30 year old forest of Scotch pine.



K-2170 May 23, 1952
South of Glendye. Microrelief of the peaty,
gley, heather Podzol.



K-2171 May 23, 1952
North of Fettercairn. View of hill peat.



K-2172 May 23, 1952
North of Fettercairn. Microrelief in
hill peat.

We stop to go over the Bent-Lawrencekirk farm operated by Mr. John Mackie.

This is a large dairy and poultry farm run very efficiently. I am told that Mr. Mackie has two other very large farms besides this one. Although he (Mr. Mackie) is away, the foreman shows us over the place. I see hay drying and grass silage being made. For silage, the hay is cut, hauled in direct from the field, and packed with a tractor in a trench silo between two stone walls. No material is added besides the grass and a surface 8-inch layer of soil. The dried hay is baled. Part is used in the dairy, part for poultry, and a part is sold.

The foreman gives me the following figures on production from this farm:

Seed potatoes -- 96 acres

Wheat -- 40 acres

Barley -- 162 acres

Kale -- 3 acres

Turnips -- 19 acres

Oats -- 102 acres

Grass -- 284 acres

Laying hens -- 3,000.

The farm produces 430 gallons of milk per day from about 120 cows.



K-2173 May 23, 1952
Bent-Lawrencekirk farm. Milking stalls.



K-2174 May 23, 1952
Bent-Lawrencekirk farm. Making grass
silage.



K-2175 May 23, 1952
Bent-Lawrencekirk farm. Picking up
freshly-cut grass for silage.



K-2176 May 23, 1952
Bent-Lawrencekirk farm. Hauling freshly-cut
grass to trench silo.

Most of the work is done with tractors. There is a staff of 35 with 14 houses for married men and two hostels, one for unmarried men and one for women. The married women do little or no farm work.

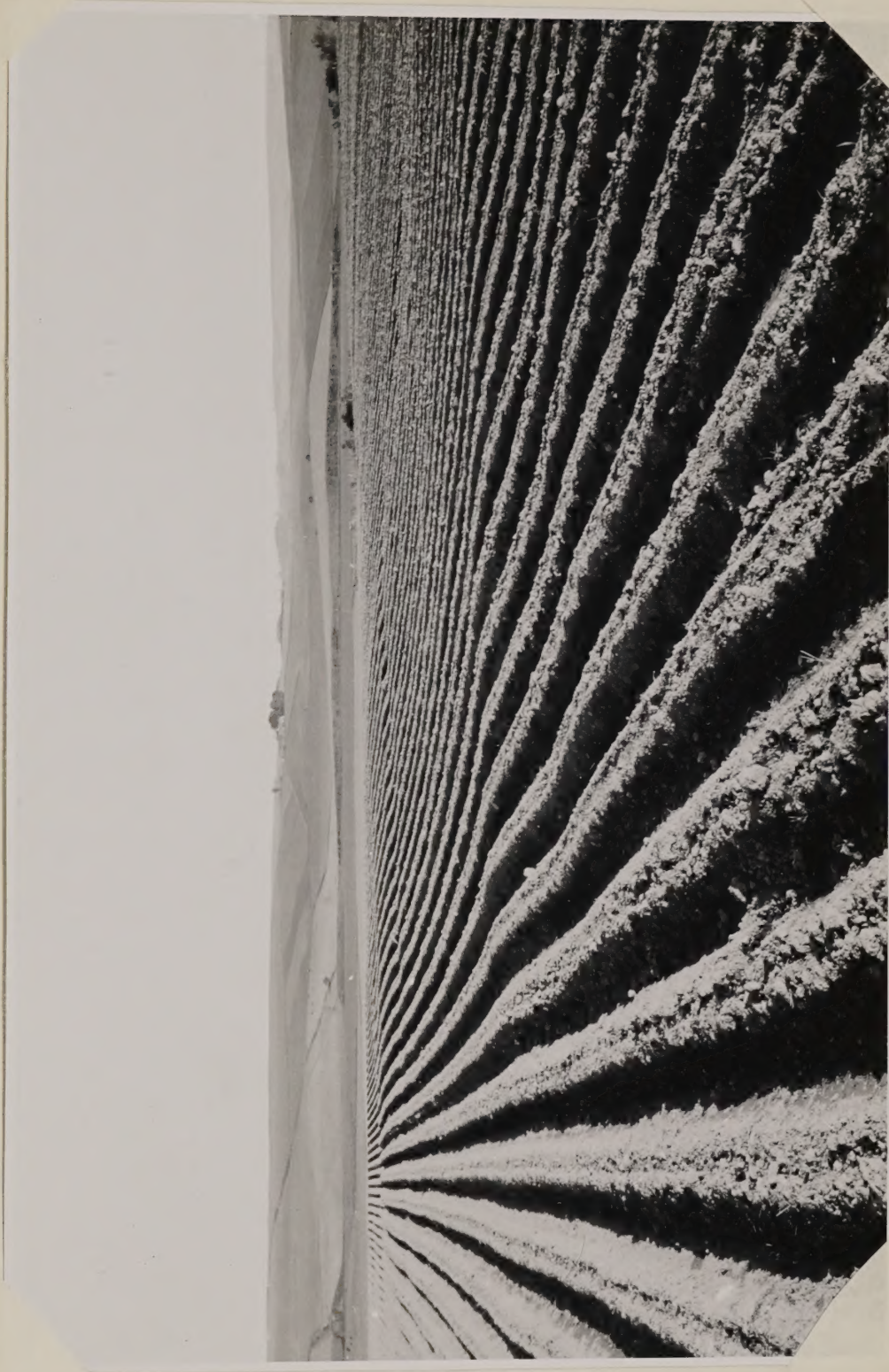
Some recreational facilities have been built and others are still under construction. One of the men on this farm got 20,000 pounds in a lottery, but stays on his job.

Just as we leave I look at the soil near the buildings. It is a reddish clay loam from marly sandstone. I should call it a weakly-developed Gray-Brown Podzolic soil.

We then go to the Gardenstone Arms of Lawrence Kirk for tea at 6:00 p.m. Although my stomach is o.k., my back is very sore after this day. I am told that Bobby Burns stayed in this pub and wrote the name of one of his girls on a window pane with a diamond ring. I am shown the pane, but of course I don't know who wrote it. Samuel Johnson and Boswell also stayed in this club on their famous trip to the Hebrides.

We leave for Aberdeen about 7:15. I try for pictures along the road, especially to show how the turnips and potatoes are ridged.

We are back to Aberdeen at 7:30. After a little chit-chat with the Stewarts, I am off to bed.



K-2177 May 23, 1952
Northeast of Lawrence^{KS}. Characteristic turnip field **on** Lawrence^{KS} soil.
Plants just emerging.

Литература
К-5111
№ 52
1935

Литература
К-5111
№ 52
1935

П-1111



K-2178 May 23, 1952
Southwest of Stonehaven. Characteristic
farmstead.



K-2179 Southwest of Stonehaven. Characteristic farmstead.

RECEIVED 20 SEP 1964. CRYSTALLOGRAPHIC INFORMATION.

152129

May 24

This is a nice bright morning. I go again to the Macaulay Institute to get some pictures in the garden and to talk with some more of the staff members. Just before lunch Dr. Stewart takes me to Aberdeen University where I call on Dr. W. H. T. Williamson. Williamson tells me that soil science is a separate department here in the faculty of science. He has about 50 undergraduates in soils, 24 in agriculture, 14 in forestry, 2 in science, 2 with minors in botany, and 8 or 12 with minors in geography. There are 6 graduate students in soils. Two of these are from the Colonial Office and also work at the Macaulay.

After short visits with some of the staff I go to lunch with Dr. and Mrs. Williamson. After lunch he takes me over to the new quarters of soil science in a new building at King's College. These are very nice quarters indeed. I have never seen a better layout of rooms and laboratories for teaching soil science. I take a quick look at the chapel and some of the other old buildings of King's College that go back before the days of the Bonny Prince Charles.

In the middle of the afternoon he takes me back to the Stewarts' house and I have time for a short nap. Just



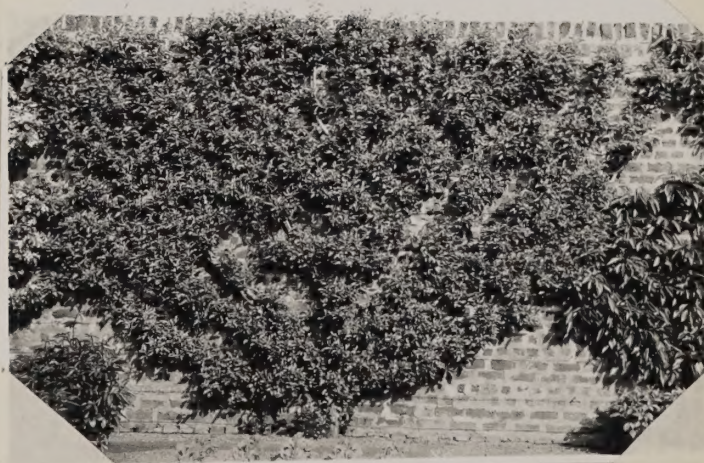
K-2180 May 24, 1952
Aberdeen Macaulay Institute. Apples trained cordon.

17
P-111A

SEP 18 1965
U.S. AIR FORCE
RECEIVED



K-2181 May 24, 1952
Macaulay Institute. Aberdeen. Apples espalier.



K-2182 May 24, 1952
Macaulay Institute. Aberdeen. Apples
espalier.

as I finish bringing my accounts up to date, Mr. and Mrs. Stewart
 come in. We have tea, chat a while, and they take me to the
 train. I leave Aberdeen at 7:30 p.m. Despite the short visit,
 this visit and stay was very pleasant.

The grass on the hill in the wild places is a primeval forest
 but the yellow birch is the dominant tree in the
 deciduous forest. The
 white birch, the
 the fields are
 United Kingdom.

I like the
 Although the



Because of the early
 Macaulay Institute. Aberdeen. Apples
 recorded when the
 before the plants are past their prime, when all the
 had to be done by hand every day.

I write the



K-2184 May 24, 1952
 Macaulay Institute. Aberdeen. Apples
 trained cordon.

as I finish bringing my accounts up to date, Dr. and Mrs. Stewart come in. We have tea, chat a while, and they take me to the train. I leave Aberdeen at 7:10 p.m. Despite the sore back, this visit and stopover has been very pleasant.

The gorse one sees in the wild places is a prickly nuisance, but the yellow blooms are very nice indeed, especially in massive clumps. Relatively small fields are surrounded by stone walls. But here on the good soil of the coastal strip, the fields are not so small as in many other parts of the United Kingdom.

I like the old low stone barns one sees from the train. Although picturesque, they are really a great handicap. Because of the massive stone walls, it is nearly impossible to remodel them in any way. They were built a long time ago before electricity or gasoline motors, when all the work had to be done by hand any way.

I settle down to sleep about 8:30.

May 25

I arrive at King's Cross Station in London a little after 7:00 and take breakfast in a hotel across from the station. After many false starts, much misdirection, and unnecessary carrying of bags, I finally reach the proper bus stop for Harpenden.

The Muirs meet me in Harpenden and we go to lunch together at Old Cock Inn.

I try to rest for a while in the afternoon in order to prepare for a night without sleep. This doesn't work very well.

I take the last train to London at 10:10 and get to the Victoria Air Station a little after 11:00. My plane was to have left London at a respectable hour -- 1:45 p.m. tomorrow. I was told that I should leave at 1:45 a.m. tomorrow and to be here at the air station at 11:45. Now they tell me even this is incorrect. So one day passes to another while I sit and wait for the bus.

May 25

I arrive at King's Cross Station in London a little after 7:00 and take breakfast in a hotel across from the station. After many false starts, much misdirection, and unnecessary carrying of baggage, I finally reach the proper bus stop for Harpenden. The bus meets me in Harpenden and we go to lunch together at Old Cock Inn. I try to rest for a while in the afternoon in order to prepare for a night without sleep. This doesn't work very well. I take the last train to London at 10:10 and get to the Victoria Air Station a little after 11:00. My plane was to have left London at a respectable hour -- 1:15 p.m. tomorrow. I was told that I should leave at 2:15 a.m. tomorrow and to be here at the air station at 11:15. Now they tell me even this is incorrect. So one day passes to another while I sit and wait for the bus.

May 24

We leave the ship at 10:00 AM and arrive at the London Airport at 11:30 AM. I learn that our plane has not yet arrived and that the old story is before.

I have breakfast at about 11:30 AM. Finally the flight comes along, but it is very late.

Saylight soon and I still.

Finally we take off for the

10:00 AM and time we are now

too early for the flight to leave

because the flight is now

difficult to get a ticket to call through to the plane

Harpenden, and it is out of the plane.

We leave at 10:00 AM.

Greenland is now

is Jaggidly and

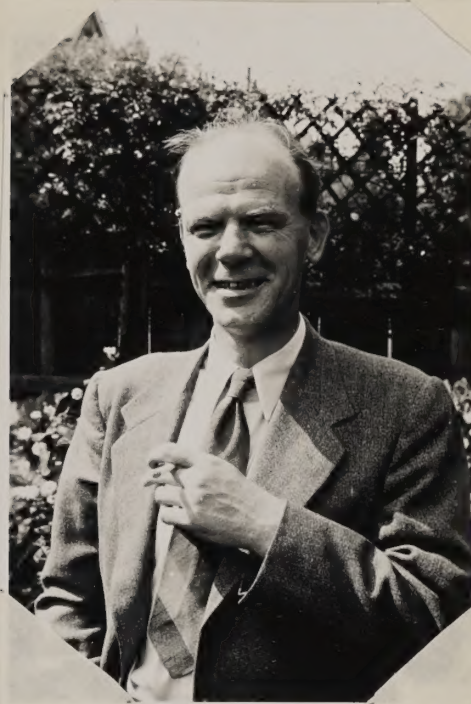
I can see now

Big drink of

strip is very

are 10:00 AM.

a relatively



K-2185 May 25, 1952
Harpenden. Dr. Muir.



K-2186 May 25, 1952
Harpenden. Dr. Muir and family.

May 26

We leave the Victoria Air Station at 1:25 a.m. and arrive at the London Airport at 2:10 a.m., in time to learn that our plane has not even left Paris! The same old story as before.

I have breakfast at about 3:00 and wait and wait and wait. Finally the flight comes in from Israel, and a more sleepy, bedraggled, funny looking bunch of people I have never seen.

Daylight comes and I still wait.

Finally we take off for Iceland at 5:18 a.m. At 10:00 Iceland time we are down at Keflavik. It is a bit too early for lunch so I have two breakfasts of cakes and bacon (assuming that my stomach is O.K. now). After much difficulty I get a telephone call through to Dr. Bjorn Johannesson, only to find that he is out of the city.

We leave at 11:32 a.m. for North America. At 3:05 p.m. Greenland comes in view. The land I see along the coast is jaggedly hilly and more than one-half covered with snow. I can see some small valley glaciers flowing into the sea. Big chunks of ice break off and float away. This coastal strip is very narrow and most uninviting. Apparently we are flying over the southern tip. Far to the north I see a relatively smooth, high ice field with a few up-thrusting



View of Greenland from plane.



View of Greenland from plane.



View of Greenland from plane.

rocky peaks. Directly beneath the plain is a mass of jagged peaks, small glaciers, and snow fields.

I try for pictures just as we leave the southwestern coast. Here the relief is lower and the coastal strip somewhat wider.

The hours pass very, very slowly indeed. The plane seats are so near together that no one can get comfortable. Fortunately the weather is fine. If the flying got rough a lot of people would be hurt from the baggage piled in the racks. Then too, I have never seen people in a plane move about so much. Many of them are continually walking up and down the aisles.

We come into Goose Bay about 6:30 p.m., Iceland time, or about 2:36 New York time. There are small patches of snow on the highest places and in the woods. Our pilot has a lot of trouble getting down. Here at the airport it is beautifully sunny and warm.

We leave Goose Bay at 3:48 E.S.T. for the last lap of the trip. Most of the time we fly over clouds. I don't think the time has ever gone more slowly for me than in this uncomfortable plane.

We are down at Idlewild Airport at 8:55 p.m. After the usual wait for formalities I am through customs at

9:45. I get a reservation to Washington, call home,
and have a light lunch. Washington Airport at 11:45 P.M.

I get into the plane at 11 o'clock and for some
reason we wait 50 minutes, so this day passes to the
next a little out of New York.

May 28

We are down at the Washington Airport at 12:45 p.m.
Mrs. Kellogg is there to meet me and I am home once more
at 1:30 p.m. and very, very glad to be here.



THE NEGEV ROAD
FROM BEERSHEBA TO ELATH

מדינת ישראל מוזי התחבורה
State of Israel Tourist Dept.

כביש הנגב
מבאר שבע לאילת

LE CHEMIN DU NEGEV
DE BEERSHEBA A ELATH

כל הזכויות שמורות
PHOTO: PRIOR



TEL-AVIV - JAFFA

כל הזכויות שמורות
 PHOTO: KLUGER

תל־אביב - יפו

מדינת ישראל מחזקת התיירות
 State of Israel Tourist Dept.

TEL-AVIV - JAFFA



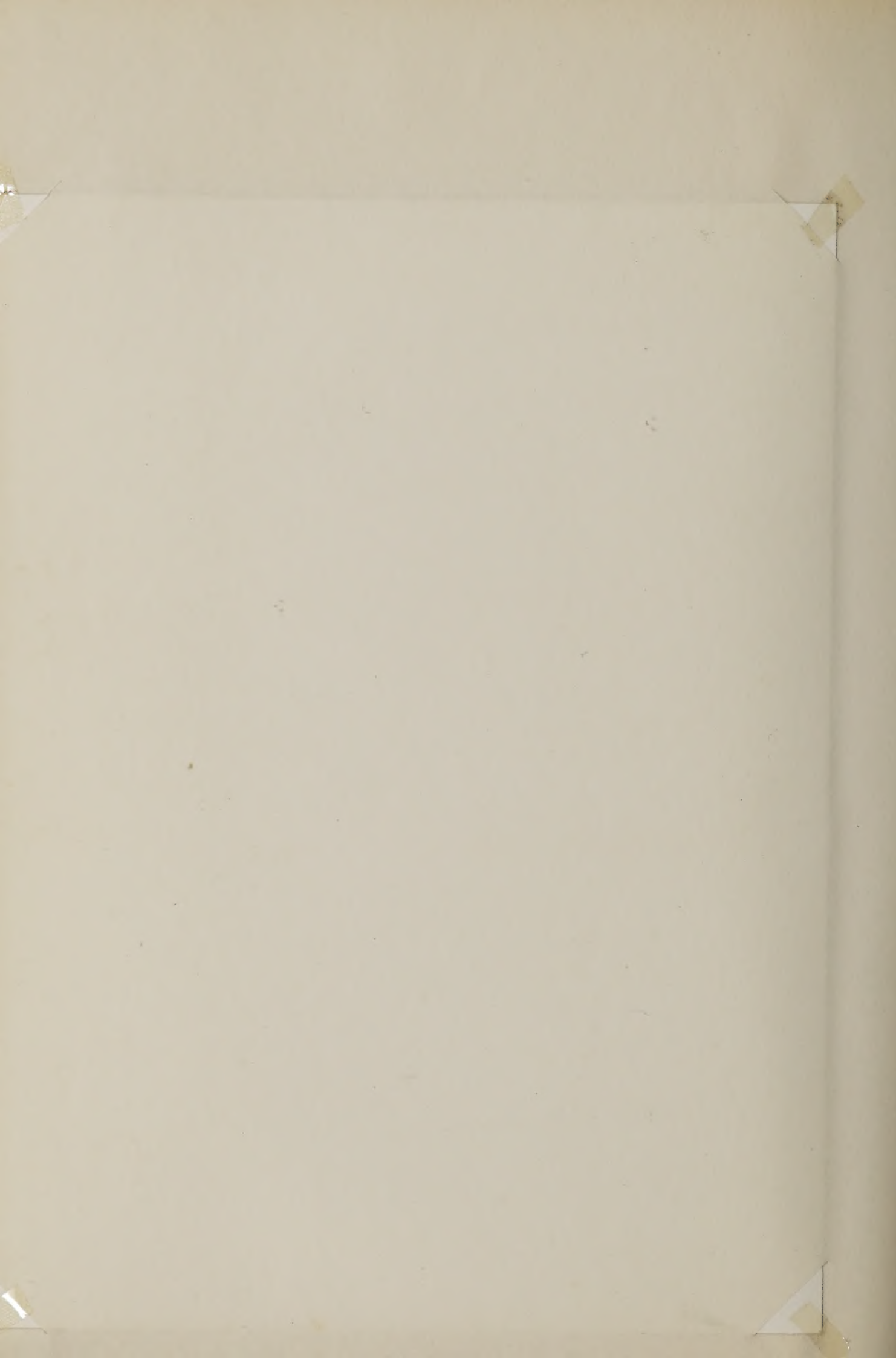
THE RIVER JORDAN
NEAR THE SEA OF GALILEE

ה י ר ד ן
ליד הכנרת

LE JOURDAIN
PRÈS DU LAC DE GALILÉE

מדינת ישראל מח' התיירות
State of Israel Tourist Dept.

כל הזכויות שמורות
PHOTO: KLUGER





RAMLEH
THE ANCIENT WHITE TOWER

ר מ ל ה
המגדל הלבן העתיק

RAMLEH
L'ANTIQUE TOUR BLANCHE

מדינת ישראל מחי' התיירות
State of Israel Tourist Dept.

כל הזכויות שמורות
Photo: Govt. Info. Services

FOLK - DANCES

A KIBBUTZ DALIAH

מדינת ישראל מח. התיירות
State of Israel Tourist Dept.

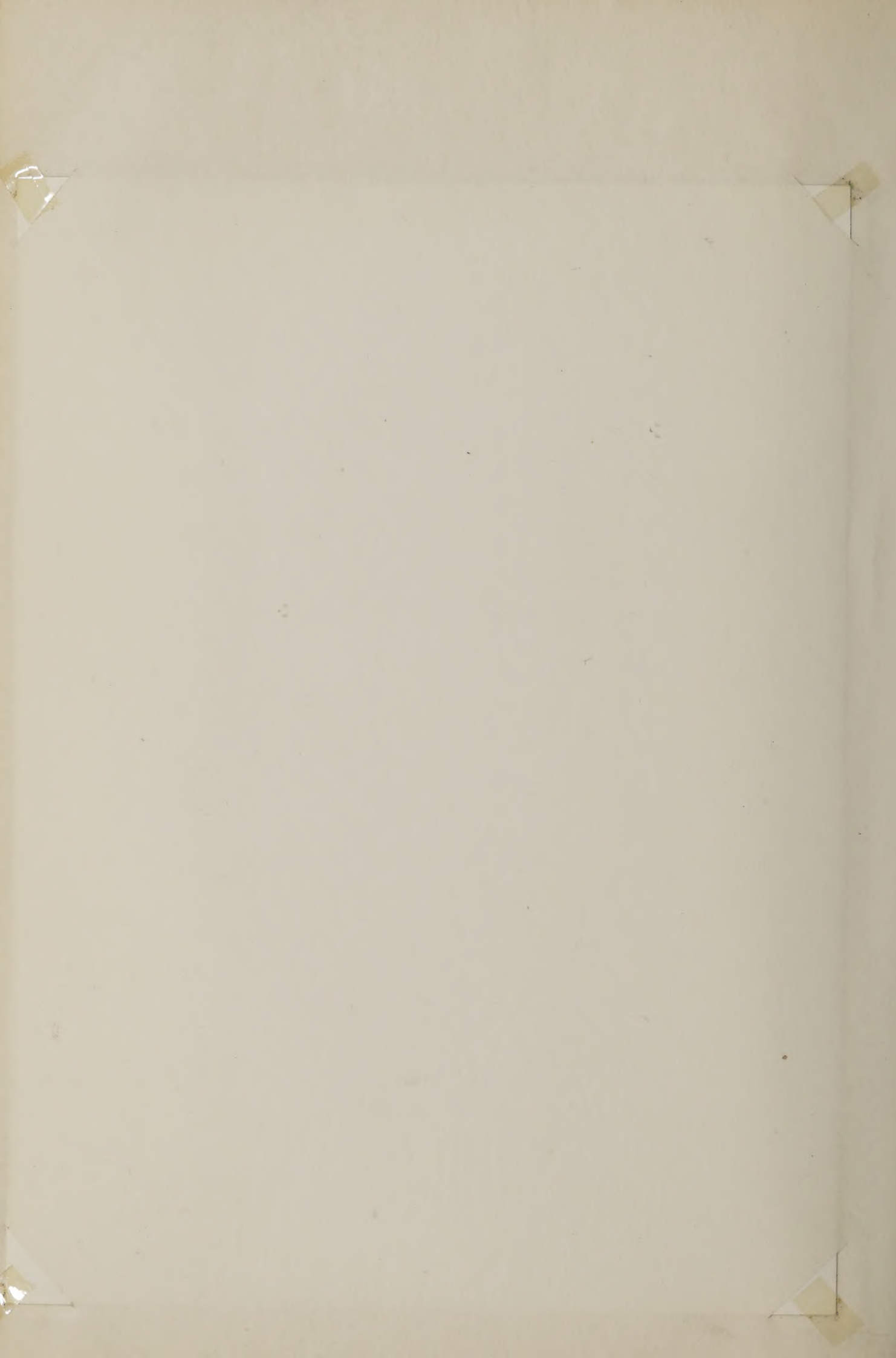
ר ק ו ד י ע ם ב ק בוצ ד ל י א

DANSES TRADITIONELLES

A KIBBOUTZ DALIAH

כל הוכיות שמורות
PHOTO: KLUGER





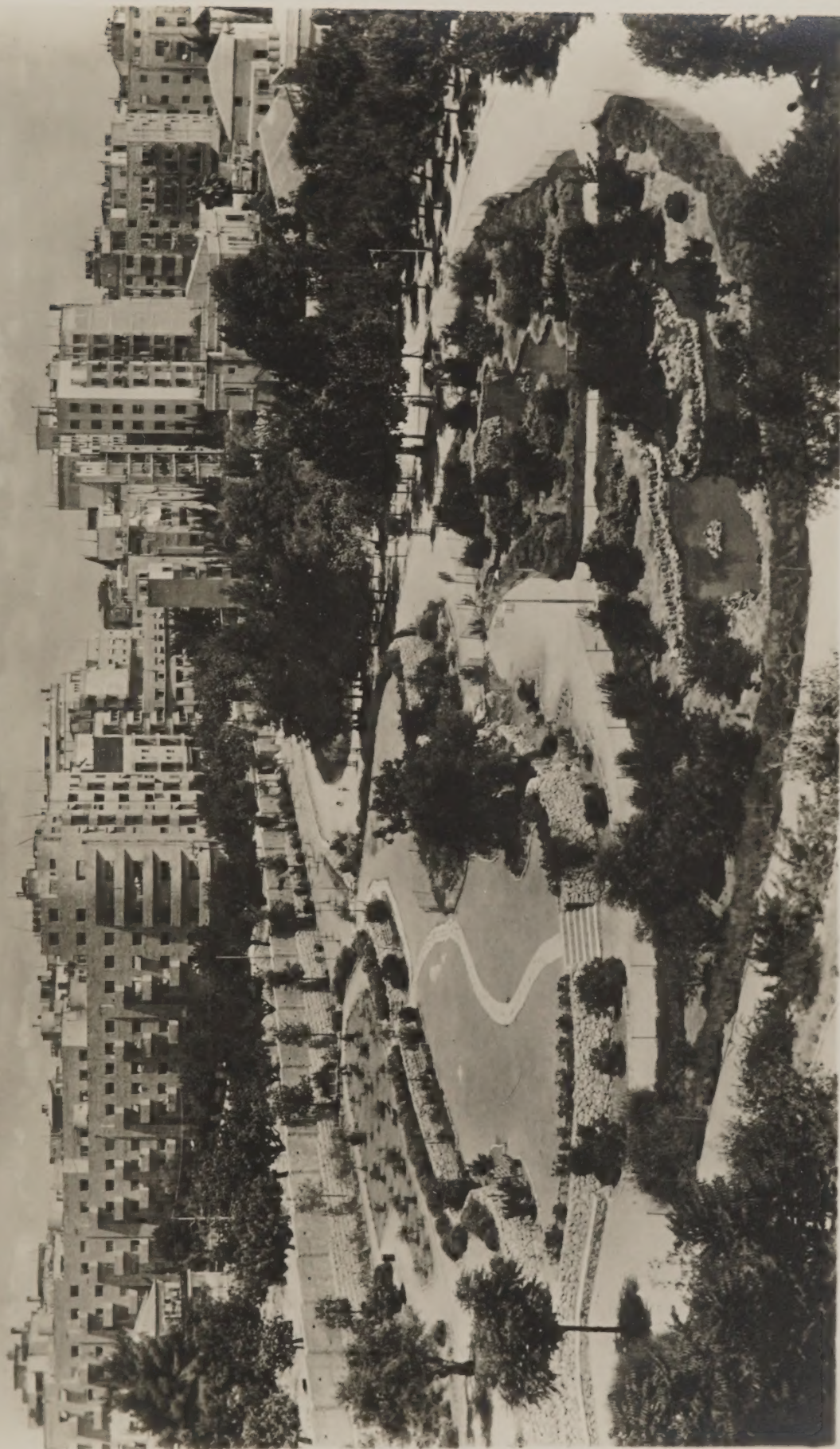
JERUSALEM

כל הזכויות שמורות
Copyright by "Palphot"

יְרוּשָׁלַיִם

מדינת ישראל מוזי התירות
State of Israel Tourist Dept.

JERUSALEM







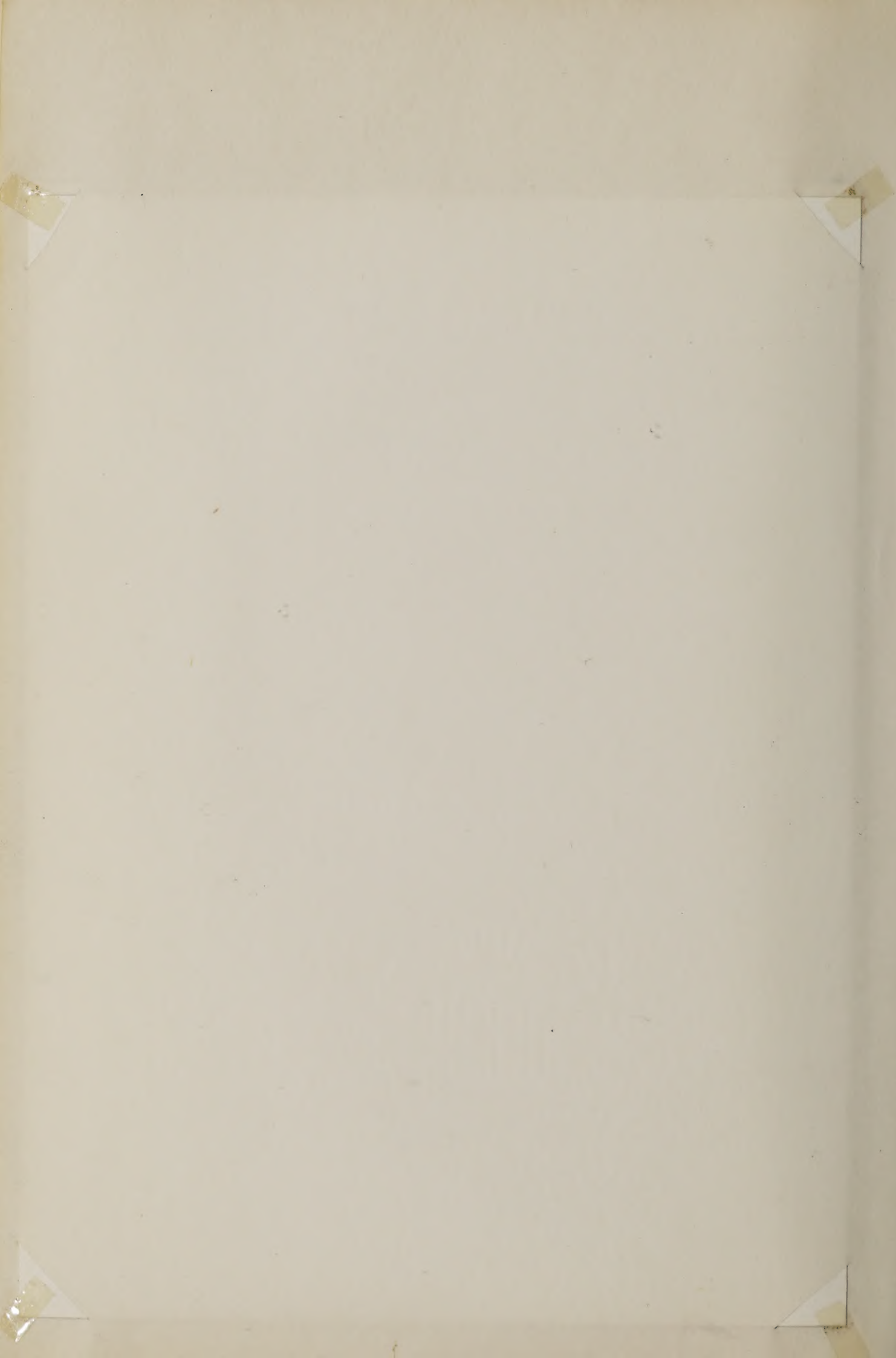
NAZARETH

נצרת

NAZARETH

מדינת ישראל מוזי תיירות
State of Israel Tourist Dept.

כל הזכויות שמורות
PHOTO: KLUGER





KEFAR SHMARYAHU
A VILLAGE IN THE SHARON

כפר שמריהו
בשרון

KEFAR SHMARYAHU
UN VILLAGE DANS LE SARON

מדינת ישראל מחלקת התיירות
State of Israel Tourist Dept.

כל הזכויות שמורות
Copyright by "Palphot"



SAFAD

צ פ ת

SAFAD

כל הזכויות שמורות
Photo: Jewish Agency

מדינת ישראל מוז' התיירות
State of Israel Tourist Dept.



EIN GEV
A COLLECTIVE SETTLEMENT
ON THE SEA OF GALILEE

קבוץ עין-גב
על גדות הכנרת

מדינת ישראל מוזי התיירות
State of Israel Tourist Dept.

EIN GEV
UN VILLAGE COLLECTIF AU
BORD DU LAC DE GALILEE

כל הזכויות שמורות
Photo: Govt. Info. Services





HAIFA AT NIGHT

חַיפָּה בַּלַּיְלָה

NUIT A HAIFA

מדינת ישראל מחלקת התיירות
State of Israel Tourist Dept.

כל הזכויות שמורות
Copyright by 'Alphot'



KING DAVID'S TOMB
MT. ZION, JERUSALEM

קבר דוד המלך
על הר ציון, ירושלים

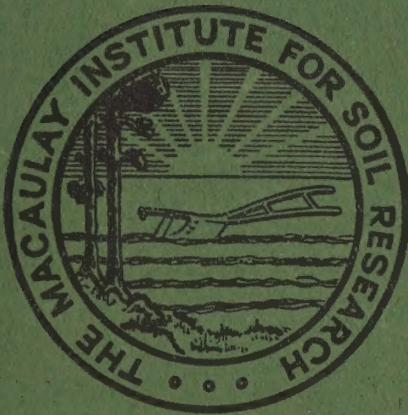
LE TOMBEAU DU ROI DAVID
MT. SION, JERUSALEM

מדינת ישראל מח' התיירות
State of Israel Tourist Dept.

כל הזכויות שמורות
PHOTO: KLUGER

KELLOGG

THE MACAULAY INSTITUTE FOR SOIL RESEARCH

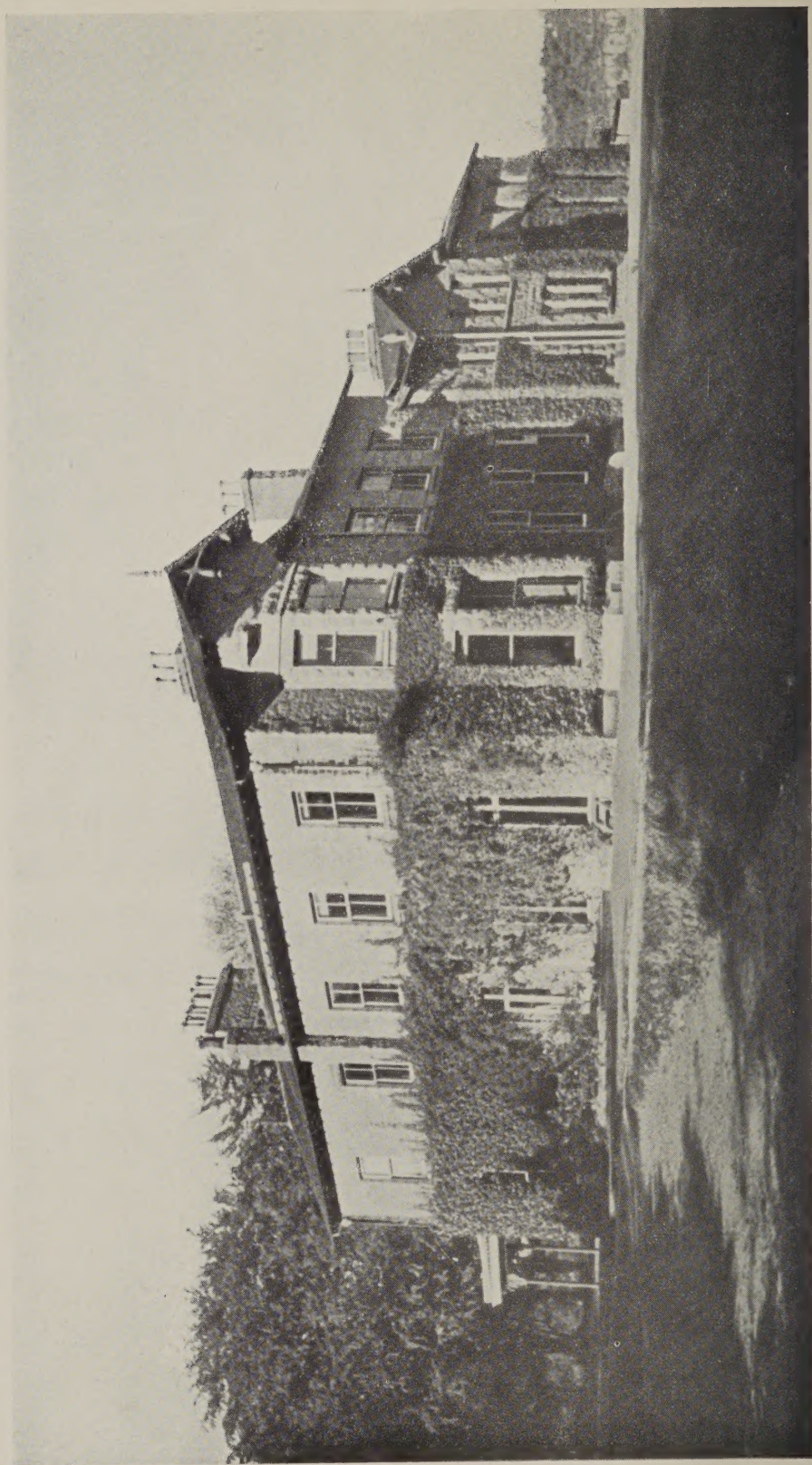


FOUNDED 1930

ANNUAL REPORT 1950-1951

The Macaulay Institute is situated in Countesswells Road, about three miles from the centre of Aberdeen. Buses (Route 18) run at frequent intervals from Union Street to the Seafield terminus which is within 10 minutes walk of the Institute.

Telephone—ABERDEEN 33223



THE MACAULAY INSTITUTE FOR SOIL RESEARCH

THE MACAULAY INSTITUTE FOR SOIL RESEARCH

CRAIGIEBUCKLER, ABERDEEN
(Founded 1930)

COUNCIL OF MANAGEMENT

1950-1951

Chairman—

PROFESSOR J. R. MATTHEWS, M.A., F.L.S., F.R.S.E.

Appointed by the Department of Agriculture for Scotland—

PROFESSOR E. L. HIRST, D.Sc., LL.D., F.R.S.

M. MACGREGOR, ESQ., M.A., D.Sc.

R. G. WHITE, ESQ., C.B.E., M.Sc., F.R.S.E.

Appointed by the University of Aberdeen—

PROFESSOR W. O. KERMACK, M.A., D.Sc., LL.D., F.R.S.

PROFESSOR J. R. MATTHEWS, M.A., F.L.S., F.R.S.E.

PROFESSOR T. C. PHEMISTER, D.Sc., Ph.D., M.Sc. (Chicago), D. de l'Univ. (Rennes).

Appointed by The North of Scotland College of Agriculture—

LIEUT.-COL. G. B. DUFF, D.S.O.

MAJOR JAMES KEITH, C.B.E.

MAITLAND MACKIE, ESQ., O.B.E.

Appointed by The West of Scotland Agricultural College—

PROFESSOR C. M. YONGE, D.Sc., Ph.D., F.R.S.

Appointed by The Edinburgh and East of Scotland College of Agriculture—

PRINCIPAL S. J. WATSON, D.Sc., F.R.I.C.

Co-opted—

EMERITUS-PROFESSOR A. FINDLAY, C.B.E., M.A., D.Sc., Ph.D., LL.D., F.R.I.C.

JAMES MACDONALD, ESQ., B.Sc.

SIR WILLIAM GAMMIE OGG, M.A., B.Sc. (Agr.), Ph.D. (Cantab.), LL.D.

PROFESSOR H. M. STEVEN, M.A., B.Sc., Ph.D., F.R.S.E.

PRINCIPAL T. M. TAYLOR, C.B.E., K.C., M.A., LL.D.

STAFF

1950-1951

Director:

D. N. McARTHUR, D.Sc., Ph.D., F.R.I.C., F.R.S.E.

Deputy Director:

A. B. STEWART, M.A., B.Sc., Ph.D., F.R.I.C.

Pedology

Soil Survey (Scotland)

R. GLENTWORTH, B.S.A. (MANITOBA), Ph.D.
 J. W. MUIR, B.Sc.(AGR.), A.R.I.C., N.D.A., N.D.D.
 J. C. C. ROMANS, B.Sc.
 B. D. MITCHELL, B.Sc.
 D. T. DAVIES, B.Sc.
 †P. C. HARPER, B.Sc.
 †M. J. MULCAHY, B.Sc.(For.).
 R. GRANT, M.A., B.Sc.
 *R. A. ROBERTSON, B.Sc.
 *J. M. RAGG, B.Sc.
 *D. LAING, B.Sc.

Soil Geology and Mineralogy

R. HART, B.Sc., Ph.D.

X-ray Investigations

†G. F. WALKER, B.Sc., Ph.D.

*W. A. MITCHELL, B.Sc.

MISS A. A. MILNE, B.Sc.

Physico-Chemical Investigations

R. C. MACKENZIE, B.Sc., Ph.D., A.R.I.C.
 MISS K. R. FARQUHARSON, B.Sc.

Analytical Section

H. G. M. HARDIE, Ph.D., A.R.I.C.

Spectrochemistry

R. L. MITCHELL, B.Sc., Ph.D., F.R.I.C.
 R. O. SCOTT, B.Sc., Ph.D., A.R.T.C., A.R.I.C.
 V. C. FARMER, B.Sc., Ph.D.
 MRS I. M. JOHNSTON, B.Sc., A.R.I.C.
 A. M. URE, B.Sc.
 *I. W. M. A. BLACK, B.Sc., Ph.D.

Soil Organic Matter

G. K. FRASER, M.A., B.Sc.(For.), D.Sc.

Biochemistry

R. I. MORRISON, B.Sc., Ph.D., A.R.I.C.
 R. B. DUFF, B.Sc., Ph.D.

Microbiology

D. M. WEBLEY, B.Sc., M.Sc., Ph.D.
 T. M. FORRESTER, B.Sc.

Peat Investigations

S. E. DURNO, B.Sc.

Forest Soil Investigations

*T. W. WRIGHT, B.Sc.(For.).

Plant Physiology

J. G. HUNTER, B.Sc., Ph.D., F.R.I.C.
 W. M. CROOKE, B.Sc., A.R.I.C.

Radioactive Studies

A. H. KNIGHT, B.Sc., A.R.I.C.

Soil Fertility—Chemistry and Field Experimentation

A. B. STEWART, M.A., B.Sc., Ph.D., F.R.I.C.
 E. G. WILLIAMS, B.Sc., Ph.D.
 MISS A. J. PREDDY, M.A.
 J. W. S. REITH, B.Sc.(AGR.), Ph.D., A.R.I.C.
 ‡H. D. WELSH.
 J. R. DEVINE, B.Sc.(AGR.).
 R. H. E. INKSON, B.Sc.
 N. M. SCOTT.

Precision Instrument Maker

A. M. FRASER.

Secretary

MISS E. J. DEY

Librarian

MISS A. M. B. GEDDES, M.A., F.L.A.

*Appointed 1951

†Resigned 1951

‡Retired 1951

POST-GRADUATE RESEARCH WORKERS

- E. ERIKSSON (Royal Agricultural College, Uppsala, Sweden).
R. A. HIGAZY (University of Alexandria, Egypt).
✓ L. H. P. JONES (University of Melbourne, Australia). *Mn*
S. G. KRISHNAMURTY (Presidency College, Madras, India).
M. MUÑOZ TABOADELA (Instituto de Edafologia y Fisiologia Vegetal, Madrid, Spain).
J. RAMIREZ MUÑOZ (University of Madrid, Spain).
D. V. K. RAO (Agricultural Research Institute, Coimbatore, India).
SUSANA M. de SALAS (University of Buenos Aires, Argentina).
✓ W. M. H. SAUNDERS (Department of Scientific and Industrial Research, Wellington, New Zealand).
G. SEMB (Agricultural College, Vollebekk, Norway).
J. SPECTOR (Imperial College of Tropical Agriculture, Trinidad).
D. J. SWAINE (University of Melbourne, Australia).
I. T. TWYFORD (Colonial Office, London).
A. C. VENN (Colonial Office, London).
ORNELLA VERGNANO (University of Florence, Italy).
R. P. ST. J. WATKIN (Government Chemists' Department, Tanganyika).
J. WYLLIE (Queen's University, Kingston, Ontario, Canada).
O. YAMANLAR (University of Istanbul, Turkey).

CONTENTS

	PAGE
INTRODUCTION	5
PEDOLOGY	8
SPECTROCHEMISTRY	20
SOIL ORGANIC MATTER	24
PLANT PHYSIOLOGY	28
SOIL FERTILITY—CHEMISTRY AND FIELD EXPERI- MENTATION	31
PUBLICATIONS	36
APPENDIX	40

INTRODUCTION

The Council of Management of The Macaulay Institute is again grateful to the Department of Agriculture for Scotland, to the Agricultural Research Council, and to the Forestry Commission for grants in aid of the work, and to other benefactors for their generous support.

The Institute was visited during the year by representatives of many research and experimental stations in Australia, Canada, India, New Zealand, South Africa, Argentina, Chile, France, Germany, Pakistan, Norway, Sweden, Turkey, and the United States of America. Visiting parties included members of the Society of Applied Bacteriology, the Advisory Nutrition Chemists' Conference, the Scottish Advisory Horticultural Conference, the Huntly Branch of the National Farmers' Union of Scotland, and the Le Play Society. The Agricultural Research Council held its autumn meeting on 17th September, 1951, at The Macaulay Institute and thereafter met members of staff.

VISITING RESEARCH WORKERS

Research workers from many countries have collaborated in the work of the Institute:—

Department of Pedology—

Soil Survey—

Mr A. C. Venn, Colonial Office, London.

Mr R. St. J. Watkin, Government Analytical Chemist's Department, Tanganyika.

Mr O. Yamanlar, University of Istanbul, Turkey.

Physico-Chemical and X-ray Investigations—

Dr M. Muñoz Taboada, Instituto de Edafología y Fisiología Vegetal, Madrid, Spain.

Soil Geology and Mineralogy—

Mr G. Semb, Agricultural College, Vollebakk, Norway.

Department of Spectrochemistry—

Mr R. A. Higazy, University of Alexandria, Egypt.

Dr S. G. Krishnamurty, Presidency College, Madras, India.

Dr J. Ramirez Muñoz, University of Madrid, Spain.

Dr S. M. de Salas, University of Buenos Aires, Argentine.

Mr J. Spector, Imperial College of Tropical Agriculture, Trinidad.

Mr D. J. Swaine, University of Melbourne, Australia.

Professor J. Wyllie, Queen's University, Kingston, Ontario, Canada.

Department of Plant Physiology—

Dr Ornella Vergnano, University of Florence, Italy.

Department of Soil Fertility—

Mr E. Eriksson, Royal Agricultural College, Uppsala, Sweden.

Dr L. H. P. Jones, University of Melbourne, Australia.

Mr D. V. K. Rao, Agricultural Research Institute, Coimbatore, India.

Mr W. M. H. Saunders, Department of Scientific and Industrial Research, Wellington, New Zealand.

Mr I. T. Twyford, Colonial Office, London.

REPRESENTATION ON COMMITTEES

The Institute was represented on the following Committees, appointed by—

(1) *Agricultural Research Council;*

(a) Conference on Fertilizers.

(b) Conference on Mineral Deficiencies of Agricultural and Horticultural Crops.

(c) Land Drainage Conference.

(d) Soil Survey Research Board.

(2) *Department of Agriculture for Scotland;*

(a) Scottish Agricultural Improvement Council.

(b) Field Trials Sub-Committee.

(c) Scottish Grassland Sub-Committee.

(d) Sugar Beet Sub-Committee.

(e) Consultative Committee for the Development of Spectrographic Work, and its Technical Sub-Committee.

(3) *Forestry Commission;*

The Sub-Committee dealing with Nutritional Problems in Tree Nurseries.

(4) *Colonial Office;*

Soils Sub-Committee of the Committee for Colonial Agricultural, Animal Health and Forestry Research.

(5) *Development Commission;*

Survey of Agricultural, Forestry and Fishery Products and their Utilization.

(6) *Secretary of State for Scotland;*

(a) Hill Farm Research Committee and its Sub-Committees dealing with (i) Trace Elements and (ii) Heather.

(b) The Scottish Standing Committee for the Calculation of the Residual Values of Fertilizers and Feeding Stuffs.

(c) The Scottish Peat Committee, and Sub-Committee on the Survey of Peat Deposits in Scotland.

(d) The Nature Conservancy (Scottish Committee).

(e) The Standing Advisory Committee, Fertilizer and Feeding Stuffs Act, 1926.

STAFF

The following changes in personnel took place:—

(a) *Resignations;*

Department of Pedology;

Dr G. F. Walker (X-ray Section), on appointment to the staff of the Commonwealth Scientific and Industrial Research Organization, Australia.

Mr P. C. Harper (Soil Survey Section), on receiving a scholarship (Department of Agriculture for Scotland).

(b) *Retirement;*

Department of Soil Fertility—

Mr H. D. Welsh.

(c) *Appointments;*

Department of Pedology—

Mr W. A. Mitchell, B.Sc. (X-ray Section).

Mr R. A. Robertson, B.Sc. (Soil Survey Section).

Mr J. M. Ragg, B.Sc. (Soil Survey Section).

Mr D. Laing, B.Sc. (Soil Survey Section).

Department of Spectrochemistry—

Dr I. W. M. A. Black.

Department of Soil Organic Matter—

Mr T. W. Wright, B.Sc. (Forest Soils Research).

Dr J. G. Hunter, *Department of Plant Physiology*, spent three months in the United States of America, and visited the University of California and various research centres in the United States under an award made to him in terms of the Fulbright and Smith-Mundt Acts, U.S.A.

THE WORK OF THE INSTITUTE

The maintenance and improvement of soil fertility continues to be the main objective of the work of the Institute. The staff has collaborated with sister Research Institutes, the Scottish Colleges of Agriculture and the Forestry Commission, and in the work of the various Committees of the Department of Agriculture for Scotland. Facilities have been provided for the training of research workers in various branches of soil research and for post-graduate study. Research students from overseas are studying at the Institute for higher degrees of the University of Aberdeen.

PEDOLOGY

SOIL SURVEY (SCOTLAND)

Soil survey has continued on the reconnaissance scale of 2.5 inches to 1 mile in Morayshire (Sheet 95), Aberdeenshire and Kincardine (Sheet 66), Angus (Sheet 57), Roxburghshire (Sheet 17) and Ayrshire (Sheet 22); a total area of approximately 455 square miles has been mapped. One hundred and thirty representative profiles have been collected from the survey areas.

NORTH-EAST SCOTLAND

Morayshire (Geological Survey Sheet 95)

An area of approximately 70 square miles has been surveyed. It consists of a relatively narrow coastal strip (4-7 miles wide) bounded on the north by the Moray Firth shore from Buckie to Lossiemouth and in the south by the northern foothills of the Grampians.

The topography of the area is varied. Two prominent ridges rising to over 200 feet run in a south-south-west direction from Spynie and Lossiemouth. Between them stretches the broad fertile flat of the Laich of Moray, the drained bed of the former Loch Spynie. To the south and east of the River Lossie low, smooth mounds and short ridges of sand and gravel cover the lower slopes, the ground gradually rising to a height of over 600 feet to form the foothills of the Grampians.

The two rivers of importance are the Spey and the Lossie, both flowing northwards. The wide valley of the Spey contains several well-defined terraces, while associated with the Lossie are considerable wide flat spreads of alluvium which are extensively drained by a system of artificial ditches.

The rocks are predominantly of Old Red Sandstone age and are almost everywhere covered by a thick mantle of drift. They have little direct influence on the soils of the district. Red sandstones and conglomerates of the Middle Old Red Sandstone formation occur in a three mile wide belt east of the River Spey and in smaller masses on the west bank. The rest of the area is mainly underlain by coarse-grained sandstones of the Upper formation, often with pebble bands, and fine white sandstones. The ridges near Elgin are of yellow and white sandstones of Permo-Triassic age, the latter sometimes very hard. A cherty calcareous rock in a small area near Elgin was formerly quarried and used as burnt lime. At Stotfield and Meft a cherty rock containing galena occurs.

Superficial deposits of water-sorted end-glacial material are very extensive in this area. Most widespread are morainic and fluvio-glacial sand and gravel. Lateral and terminal moraines can be traced from Loch Na Bo by Sleepieshill Wood to the Binn Hill near Kingston, and east of the Spey to Auchenhalrig. The sand covers the greater part of the area, often in the form of mounds and ridges, a fifty-foot section of bedded sand being exposed near Lesmurdie. Boulder clay probably underlies most of these spreads, but

outcrops are rare. It is only important as a soil parent material in the south-east and on the higher ground. Raised beach sand, dunes, and river-terrace gravels are also extensive.

The climate of the area is characterized by a low rainfall (25 to 28 inches) and much sunshine; the annual mean temperature at Elgin is 49°F. Light-textured soils are subject to drought.

The agriculture practised is largely mixed farming, with emphasis on the raising and fattening of cattle. Cereal crops include wheat, with the usual oats and barley, while rye is grown on the poorer sands. Seed potatoes are an important cash crop. Dairy farming, supplying local needs, is confined to alluvial land. Normal holdings are approximately 150 acres, but small 20-acre crofts tend to be located on certain agriculturally poor sites.

Small plantations of Scots pine in policy woodlands are found throughout the district, and to the west of Elgin there is a large, semi-natural oak-beech wood.

The following soils are found in the area:

Associations

1. Foudland *see* Annual Report, 1940-1941.
2. Boyndie *see* Annual Report, 1942-1943.
3. Strichen *see* Annual Report, 1943-1944.
4. Corby *see* Annual Report, 1944-1945.
5. Tynet New Association.

Links

Undifferentiated alluvium

Skeletal soils

These soils are described in more detail in the Appendix to this report.

Aberdeenshire and Kincardine (Geological Survey Sheet 66).

An area of approximately 95 square miles was re-surveyed in Deeside between Banchory and Ballater. Soil Associations and boundaries previously mapped were checked.

The country traversed extended from Hirn through Kincardine o' Neil to the south end of Loch Davan, across the Dee at Cambus o' May and southwards to Gathering Cairn. The southern boundary ran from Gathering Cairn to Forest of Birse, along the Water of Feugh to the Dee at Banchory, and thence north-east to Hirn.

Arable farming is largely restricted to the valleys of the Dee and its tributary Water of Feugh. The intervening upland and hill country consists mainly of steep heather-covered hills where grouse, deer and sheep are common. On the lower hills plantations are abundant.

The Dee in this area flows over quartzose schists and calc-silicate rocks, bounded on the north by granite and granitic gneiss. To the south of the Dee stretch hills of coarse porphyritic red granite, tailing out into granitic gneiss between the lower Feugh valley and the Dee.

Superficial deposits of glacial till, gravelly moraine and spreads of river gravel are most extensive in the river valleys. There is thin till on the hill-sides tailing out into rock rubble or bare rock at an elevation above 1,500 feet.

The following soils are found in this area:

Associations

1. Countesswells *see* Annual Report, 1943-1944.
2. Corby *see* Annual Report, 1944-1945.
3. Deecastle New Association.

Skeletal Soils

Hill Peat

These soils are described in more detail in the appendix.

EAST SCOTLAND

Angus (Geological Survey Sheet 57)

An area of about 60 square miles has been surveyed in Angus. About 23 square miles north of the Highland Boundary Fault, between Glenquiech and Glen Lethnot, consist of hill country. The remaining area between the foot-hills south of the Boundary Fault and a line roughly between Brechin and Tannadice is arable land, with scattered, though sometimes extensive, woods and plantations.

The hill country consists of steep heather-covered hills composed of flaggy quartzites and quartz mica-schist, with a thin but persistent covering of till, excepting on the upper slopes and summits where the soils are skeletal.

The arable land, an area of broad east to west undulations subdivided into many minor ridges and hollows, reflecting the general regional strike of the solid rock, shows a gradual fall of slope towards the river South Esk. It is underlain by Lower Old Red Sandstone beds with conglomerate and subordinate calcareous strata. The soils are developed on superficial deposits of red water-sorted material and light-textured till. South of the hills gravelly moraines are found sporadically overlying the till throughout a belt of country two miles wide; they are most common in the areas immediately south of the glens.

The hill farms are mainly concerned with sheep grazing, such arable land as is available being restricted to a limited rotation. There were extensive plantations in Glen Ogil but these are now mostly felled, and only partially replanted. On the low ground to the south, arable farms are of moderate size, about 200 acres being the average. Wheat, oats, barley, turnips and seed potatoes are among crops regularly grown; sugar beet and, to a much lesser extent, raspberries are important variants. Large dairy farms are found throughout the area.

The following soils are found in this area:

Associations

1. Corby *see* Annual Report, 1944-1945.
2. Strichen *see* Annual Report, 1944-1945.
3. Stonehaven *see* Annual Report, 1946-1947.
4. Strathfinella *see* Annual Report, 1947-1948.
5. Auchinblae *see* Annual Report, 1947-1948.
6. Craigo *see* Annual Report, 1947-1948.
7. Balrownie New Association.

Undifferentiated Alluvium
Skeletal Soils
Hill Peat

These soils are described in more detail in the appendix.

SOUTH-EAST SCOTLAND

Roxburghshire (Geological Survey Sheet 17)

Approximately ninety-five square miles have been surveyed this season in Roxburghshire. The area is bounded in the south-east by the River Teviot from Kalemouth to Hawick, and in the north by a line from the River Ettrick near Selkirk through St. Boswells to the vicinity of Kalemouth. In the west it is bounded by a line from the Ettrick near Selkirk to just west of Hawick.

The area is underlain by sedimentary rocks of Silurian and Upper Old Red Sandstone ages, and sporadically by intrusive necks and lavas of Carboniferous age. These have a marked effect upon the topography. To the east, where the underlying sedimentary rocks are Upper Old Red Sandstone, the topography is broadly rolling to hilly, but to the west, where they are Silurian, the topography is hilly with subsidiary ridges clearly defined on the hill slopes. The ridges are a direct result of the highly folded nature of the Silurian strata with an exceptionally regular south-west to north-east strike. Rock, usually the highly resistant greywacke, commonly outcrops at the apex of the ridges.

The principal drainage systems are the River Teviot with its tributary the Ale, and the River Ettrick. All these rivers flow mainly in a south-west to north-east direction.

Most of the area is covered by superficial deposits. Glacial till, which tends to become thin on the ridge tops and where the angle of slope is high, is by far the most extensive. Small isolated spreads of lacustrine deposits are scattered throughout the area covered by till of Silurian origin. These are often quite shallow and change to till at a depth less than three feet. Peat is found only under waterlogged conditions in the hollows. The rivers have extensive spreads of recent alluvium associated with them. In addition, the River Teviot has a comparatively wide fluvio-glacial terrace for most of its course.

Stock-rearing is the dominant activity in this area. Large flocks of breeding-ewes and smaller herds of hill cows are kept. Most of the young stock is sold off in the autumn. The holdings are large and cropping is, in general, directed towards the provision of winter keep for the breeding stock. A few farms in the vicinity of Ancrum crop extensively for cash sales, but this is undoubtedly exceptional for the area as a whole.

The following soils are found in this area:

Associations

- | | |
|-------------|--------------------------------------|
| 1. Bowmont | <i>see</i> Annual Report, 1948-1949. |
| 2. Hindhope | <i>see</i> Annual Report, 1949-1950. |
| 3. Minto | New Association. |
| 4. Hawick | New Association. |
| 5. Jedburgh | New Association. |
| 6. Denholm | New Association. |

Skeletal Soils

These soils are described in more detail in the appendix.

SOUTH-WEST SCOTLAND

Ayrshire (Geological Survey Sheet 22)

The soil survey of Ayrshire has been continued both in the north and south. Approximately 90 square miles have been mapped in the north and 45 square miles in the south on a scale of $2\frac{1}{2}$ inches to 1 mile. For simplicity of description, the areas are treated separately.

Northern Region

The River Garnock between Dalry and Lochwinnoch forms the western edge of the area and it extends eastwards to the neighbourhood of Mearns village and Dunwan Dam.

The topography in the south-west is gently undulating but the greater part of the area consists of hilly moorland with Neilston Pad in the north rising to 854 feet and Ballagiach Hill in the east to 1084 feet.

The area is drained by the Garnock, Dusk, Lugton and Annich Waters, all of which flow from north-east to south-west.

Basic and intermediate lavas of the Calciferous Sandstone Age underlie the greater part of the region. Carboniferous sediments (Upper and Lower Limestone and Limestone coal groups) are confined to the west and south-west. Two faulted strips of the latter also occur in the vicinity of Lochwinnoch and in the Lugton-Loch Libo area.

The northern part of the area is relatively drift free with boulder clay limited to local depressions and the more gentle slopes. In the east occurs a large tract of hummocky moraines. Other superficial deposits of alluvium, fluvio-glacial sands and gravels, and peat cover the region.

Dairy farming is the main agricultural activity, but on the higher ground where the soils tend to become shallower and pastures poorer, it gives way to sheep farming.

The following soil associations are found in this area:

- | | |
|---------------|--------------------------------------|
| 1. Ashgrove | <i>see</i> Annual Report, 1949-1950. |
| 2. Darleith | <i>see</i> Annual Report, 1949-1950. |
| 3. Kilmarnock | <i>see</i> Annual Report, 1949-1950. |
| 4. Glenmount | <i>see</i> Annual Report, 1949-1950. |
| 5. Anlaird | New Association. |

These soils are described in more detail in the appendix.

Southern Region

This area extends from the coast between Irvine and Monkton eastwards as far as Hurlford.

In the coastal region and for some distance up the Irvine valley, the topography is mainly flat with a few scattered drumlins. The remainder of the country is rolling, except at Dundonald and Craigie, where it abruptly alters to hilly—Wardlaw Hill, 477 feet and Craigiehill, 507 feet.

The Rivers Irvine and Cessnock are the main drainage systems of the area. Sedimentary rocks predominate, with Productive Coal Measures underlying the coastal and northern parts. Barren Red Sandstone rocks are found both in the north and south, with basalt of Millstone Grit Age and Upper Old Red Sandstone occupying the centre. Craigiehill and the rounded hillocks south of Dundonald are the result of teschenite and olivine dolerite intrusions.

The area is covered with superficial deposits, consisting of raised beach and windblown sands, boulderclay, fluvio-glacial sands and gravels, alluvium and peat.

Dairy farming is practised throughout the area.

The following soils are found in this area:

Associations

- | | |
|---------------|--------------------------------------|
| 1. Kilmarnock | <i>see</i> Annual Report, 1949-1950. |
| 2. Dreghorn | <i>see</i> Annual Report, 1949-1950. |
| 3. Rowanhill | New Association. |
| 4. Dundonald | New Association |
| 5. Bargour | New Association. |

Links

Alluvium

Hill and Basin Peat

These soils are described in more detail in the appendix.

HEATHER SURVEY

Mr R. A. Robertson, ecologist, has commenced a study of heather in collaboration with the Hill Farm Research Committee. The survey has begun in the north-east and aims at collecting data on approximate age, health, habit, type and stability of vegetation and on methods of management and stocking, as a preliminary to large-scale experiments on management of heather moors.

SPECIAL SURVEYS

The following special surveys have been made and reports submitted:

1. A textural survey of sugar-beet fields in the Lothians to assist in the investigation of the incidence of "strangles," a disease of sugar beet.
2. A survey of the haughland (alluvium) of the Spey valley; this area may at some future date be reclaimed.
3. A survey of an area between Nairn and Inverness to ascertain the extent of a calcareous (marl) subsoil.
4. An investigation of the soils of Montreathmont Forest, Brechin, where extensive areas of Scots pine have died out.
5. A survey of estuarine clay on the South Esk estate, Montrose, to determine its suitability for ceramic purposes.

LABORATORY INVESTIGATIONS AND COLLABORATIVE WORK

Work has continued on the study of the hydrologic sequence of soils with reference to (i) the pore space distribution, (ii) the fractionation of the phosphate content, and (iii) methods of investigating free sesquioxides.

Collaboration with the X-ray and Physico-Chemical Sections has been maintained in supplying a collection of weathered granites, manganese oxide and also clay samples from selected soil profiles. Additions have been made to the collection of rock specimens characteristic of the soil associations. Assistance in the selection of sites for field experiments has been given to the Department of Soil Fertility.

Co-operation has been maintained with the Departments of Soil Science, Geography, and Botany of the University of Aberdeen, and with the Scottish Colleges of Agriculture.

Soil monoliths were collected for exhibition at the Royal Highland Show in Aberdeen.

An account of the soils of Bowmont Forest, Roxburghshire, was given to the Forestry Section of the British Association.

Seven members of the Survey staff attended the Soil Surveyors Conference in Lancashire from 9th-14th September, 1951.

MAPS

1 inch to 1 mile Soil Survey maps of Ordnance Sheets 86 and 96 (3rd ed.) have been completed, and line copies have now been supplied by the Ordnance Survey for checking³³. A descriptive Memoir of the areas is being prepared.

ANALYTICAL SECTION

Routine analyses of the soil samples taken by the Soil Survey Section during the 1949 season have been completed. During 1950 some 470 samples, representing 100 profiles, were taken by the soil surveyors, and on these moisture, loss on ignition, pH, carbon, nitrogen and readily soluble phosphorus have been determined. Mechanical analyses and exchangeable cation determinations have been completed on 70 of the profiles.

A start has been made to the routine analyses of some of the soil profiles taken by the Soil Survey Section during 1951.

Clay samples from typical wet and dry profiles of the Inch, Foudland, Tarves and Hatton Associations have been separated and analysed for silica-sesquioxide ratios. Free sesquioxide determinations have also been completed on the soils from these profiles.

Special Investigations

(1) Nine profiles—36 samples—have been examined for moisture, loss on ignition, pH value, mechanical analyses, exchangeable cations, carbon, nitrogen, total and readily soluble phosphorus, in connection with a survey at Faskally, Pitlochry, for the Brown Trout Research Laboratory (Scottish Home Department).

(2) Routine analyses have been made of 6 profiles—27 samples—from Bowmont Forest, Roxburghshire, on behalf of the Forestry Commission.

(3) At the request of Lord Southesk, Brechin, mechanical analyses and exchangeable cation determinations have been carried out on eight samples from Arrat's Mill, with a view to their possible utilization as china clay.

(4) Two samples from Darnaway Estates, Morayshire, taken in connection with the corrosion of a copper pipe-line, have been analysed for water-soluble salts and pH values determined.

(5) Loss on ignition determinations and mechanical analyses have been carried out on 60 samples from East Lothian taken during a textural survey of sugar beet areas.

(6) Loss on ignition determination, pH values and mechanical analyses have been carried out on 42 samples from a drainage scheme being undertaken in the Spey Valley by the Engineering Staff of the Department of Agriculture for Scotland.

(7) Eighteen clay samples from Zanzibar and four from Spain have been analysed for their free sesquioxide and silica content.

SOIL GEOLOGY AND MINERALOGY

The study of the mineralogy of the fine sand fractions of soils and their parent materials has been continued. The parent materials were mainly glacial drifts of mixed lithological origin and the results served to characterize the soil associations.

In conjunction with Mr Gunnar Semb of the Agricultural College, Vollebekk, Norway, an investigation of the mineral content of certain soils and their parent materials from Rogaland County, Norway, was carried out. The soil parent materials were glacial drifts, mainly sandy moraines and till, and raised beach deposits. A variety of rock types, gneiss, granite, gabbro and schists, was associated with these deposits. Striking differences in the mineral assemblages of the soils and the glacial deposits associated with them were found and the results indicated that it would be possible to characterize the parent materials by this method. It is proposed to extend and complete this investigation on Mr Semb obtaining more material for study.

An investigation was made in conjunction with Mr E. A. Fitzpatrick, a research student of Soil Science Department of the University of Aberdeen, on the soils of Glen Muick, Aberdeenshire, where he had carried out a field survey. The basal rocks in this area are serpentine, granite and schists and these are partly overlain by till and morainic deposits. The fine sand fractions from various horizons of typical profiles were studied in detail and the various soil types characterized by the minerals present and their proportions in the fine sand fraction.

Co-operation has been maintained with the other departments in the examination of materials submitted for investigation.

North-east Scotland

The field examination of the soils of north-east Scotland was continued to determine the nature of their parent materials. Areas where serpentine and gabbroitic rock types occur were visited and samples of soils and rocks collected for further investigation in collaboration with the Plant Physiology Department.

West Scotland

A survey was made of the soils and their parent materials on various farms situated on the Campsie, Fintry and Kilsyth Hills, Stirlingshire, in the course of a joint investigation with the Animal Diseases Research Association, Edinburgh. Samples of soil and herbage from typical areas were collected for laboratory investigation. The area is underlain by rocks of the Calciferous Sandstone Series of the Carboniferous Formation and these consist of sandstone, shale, cementstone, limestone, basalt, tuff and dolerite. The lower ground is generally covered by glacial deposits and these are of very mixed lithological origin, always containing an admixture of sedimentary and igneous rock types.

South Scotland

Field work in connection with the sheep pining investigation was carried out in Selkirkshire and Dumfriesshire. The areas visited lie in the upper valley of the Ettrick and the neighbouring valleys of the Tima and Rankle Waters. These districts lie in a belt of Silurian rocks, consisting of shales, sandstones and greywackes. Soil samples were collected for laboratory investigation before further experimental work is carried out in this locality.

X-RAY INVESTIGATIONS

The survey of Scottish soil-clays has been extended and soils have now been studied from areas in Aberdeenshire, Angus, Ayrshire, Banffshire, Stirlingshire and Roxburghshire. Soil-clays from outside the north-east area, which has been the most intensely studied, show little difference in composition despite the different parent materials. Variations within the profiles show the breakdown and formation of clay minerals in the soil, for example, vermiculite forms at the expense of trioctahedral illite, and kaolinite at the expense of illite. Montmorillonite is seldom found and halloysite is even rarer. On Old Red Sandstone parent material, that is the Laurencekirk, Ordley, Stonehaven and Strathfinella Associations, haematite is found in the soil-clays. Haematite generally breaks down to goethite, lepidocrocite or amorphous material, but the fine coating of haematite on the sand grains typical of the Old Red Sandstone series must be more stable in soils than the commoner, coarser form. The difficulty of identifying lepidocrocite and boehmite (the γ iron and aluminium hydroxides) by their reflections near 6A is greater as calcium oxalate trihydrate appears on peroxidizing some soil-clays, especially those from top-soils, and gives a strong diffraction pattern with a reflection at 6.1A. New methods of separating the clays are being tried to avoid precipitating the insoluble calcium oxalate.

Among foreign soils studied have been samples from Norway, Sweden, Newfoundland, India and Spain. The Newfoundland soil-clays are similar to Scottish ones but the Scandinavian soils show clearly the importance to the soil-type of the parent material. Where, as in India, the soil processes are very advanced, kaolinite is the only silicate present, the most common minerals being iron and aluminium oxides.

Some samples from the West African Road Research Laboratory investigated by differential thermal analysis and X-ray diffraction, showed that the soils contained large amounts of a montmorillonite. This is in agreement with the field properties of the soils.

The study of granite weathering in Aberdeenshire has now been extended to samples from the pre-glacial deep weathering of this area and from rocks under peat.

Work on the structure of vermiculite has been continued with particular attention to the arrangement of the interlayer water associated with small cations and to the tetrahedral layer. Single crystal photographs have shown the same random shift of $\frac{nb_0}{3}$ in the b-axis direction as is shown by chlorites so that spot (hkl) reflections only occur where $k=3n$. Where $k \neq 3n$ the reflections are streaks and are unlikely to appear at all in powder photographs.

A note on the adsorption complexes formed by vermiculite with different organic compounds³ and a review of the knowledge of the mineral⁴ have now been published.

Iron oxides prepared under varying conditions by the Physico-Chemical Section have been studied, but many of these are amorphous to X-rays and others give poor diffraction patterns.

In a preliminary study of manganese pans, one, in a gravel deposit, contains a cryptocrystalline compound. This gives a diffraction pattern identical to a hydrated manganese oxide not previously found naturally and known only as the end product of the oxidation of manganous ion in excess sodium hydroxide. Many "manganese pans" seem to consist of quartz with a fine coating of manganese oxide.

In collaboration with the Physico-Chemical Section, the effects of dry-grinding for periods of up to 24 hours on muscovite, biolite and vermiculite have been studied by differential thermal analysis, X-ray diffraction and cation-exchange determinations. Biotite and vermiculite seem to be affected only slightly, the cation exchange capacity of biotite increasing slowly as more of the crystal edges are broken. The structure of muscovite seems to break down completely after 8 to 9 hours grinding, and on further grinding an illite is formed.

PHYSICO-CHEMICAL SECTION

Differential Thermal Analysis

The apparatus, briefly described in last year's report, continues to function very satisfactorily, and reproducibility both of rate of temperature increase and of results continues to be good. During the year two new types of specimen holder have been tested. One of these has proved quite satisfactory, although some adjustment of the programme controller will be necessary to obtain the required rate of heating. As this type is now available commercially, it is intended to make the adjustments necessary for its use.

A considerable number of thermograms of pure minerals and mixtures have been obtained, both for use as standard data and to investigate impurities. Among the more interesting samples were some of kaolin from Pugu, Tanganyika, where both kaolinite and "fireclay mineral" were found in one and the same deposit. No information as to the iron oxide impurity in some of these samples could, however, be obtained from these thermograms. The work on iron oxides has been considerably extended. Since relatively inconclusive results as to the conditions of formation and stability of "cold-precipitated" hydrated ferric oxide resulted from an extended study of soil clays from various soil types, it was considered that a more intensive investigation on the pure laboratory-prepared material might help to solve some problems. While the type of ferric oxide formed depends very considerably on the alkali employed, the ferric salt used does not seem to be critical, although anomalies have been observed in the presence of sulphate and phosphate. The effect of the former is difficult to explain, but the interference of the latter ion is to be expected. Oxides precipitated by ammonia, potassium hydroxide and diethylamine were found to be amorphous to X-rays while that precipitated by sodium hydroxide was partly crystalline. The 350°C peak on the cold-precipitated material appeared to be due to crystallization

into haematite, although some abnormalities have been observed. This work is continuing and is being extended to cover aluminium oxides on which a few preliminary results are now available. A paper on the results then available was read at a meeting of the Clay Minerals Group of the Mineralogical Society in April 1951.

Scottish soil-clays investigated showed, in general, the usual features—a mineral of the kaolinite group, illite, and in a few cases montmorillonite. In addition to those clays, some from other localities, including Africa, India and Sweden, have been examined. The Swedish clays were essentially micaceous, giving very little thermal reaction; the Indian and African clays were montmorillonitic or kaolinitic, depending upon their origin and development. For example, an Indian Black Soil had a clay of montmorillonitic composition while a red clay showed kaolinite. Lateritic clays in addition usually show pronounced peaks due to the presence of the hydrous iron and aluminium oxides, goethite and gibbsite. In this connection it may be remarked that the differential thermal analysis method generally becomes more valuable the more highly weathered the soil being investigated. Arctic or Sub-arctic clays give thermograms with very little character apart from a few diffuse peaks, the clays being essentially micaceous and relatively unweathered; soil-clays of the Temperate Zone give curves with some character, showing peaks of, for instance, kaolinite, illite, etc., but it is obvious from the curve that not all the components are accounted for; clays from Tropical or Sub-tropical regions, however, give sharp, well-defined peaks, and it is noticeable that, in most cases, all the components can be identified from their differential thermal analysis curve alone. This generalization is naturally very broad and subject to exceptions, but the results of Dr M. Muñoz Taboadela, while working here on the differential thermal analysis examination of minerals and soil-clays from Spain and from Spanish Morocco, have tended to confirm that the configuration of the thermogram may give some indication of the intensity of weathering.

The Differential Thermal Analysis Sub-Committee of the Comité International pour l'Etude des Argiles, referred to in last year's report, continues its work on the standardization of differential thermal analysis apparatus and a preliminary correlation of the results available for the "standard" minerals has been performed. A short paper on this preliminary correlation was read at a meeting of the Clay Minerals Group of the Mineralogical Society in November, 1950.

A paper on the possible application of differential thermal analysis to dust research is now in the press²³.

Other Studies

A description of the micro-method for the determination of cation exchange capacities of clays has now been published⁵, and the method has been successfully applied to various samples including ground micaceous minerals, diatomites, and Spanish clays. The semi-micro technique has been applied to the chemical analysis of clays, in connection with the problem of removal of free iron oxides. This technique has proved very useful in determining the chemical composition of the clay before and after treatment and the composition of the extract, and has given valuable information. Further work along these lines is envisaged.

Investigations on the possibility of using electrophoretic mobilities for separation of the clay minerals in mixtures have proceeded. Initially the behaviour of suspensions of pure minerals under electric fields was studied in order to give some indication of the conditions, if any, under which separation of a mixture might be expected. Investigations were confined to kaolinite and montmorillonite suspensions, since the properties of these minerals are so widely different. Several types of apparatus were tested to discover the best for quantitative measurement of mobilities using the moving-boundary method. One which had a narrow capillary tube between the two electrode compartments proved most satisfactory, although by no means ideal. Considerable difficulty was experienced in observing the boundary, especially in the case of montmorillonite, and although considerable time was spent in trying to make this boundary more visible, no success was obtained. In spite of these difficulties, however, it appeared that variation of monovalent exchangeable cation, electro-motive force, concentration of suspension and pH (over a limited range) did not permit sufficiently different rates to allow separation of a mixture, but in view of the rather crude measurements more accurate determinations were desirable. These were obtained through the courtesy of Dr T. R. Bolam, Department of Chemistry, University of Edinburgh, in granting facilities for the use of the ultramicroscope there to determine electrophoretic velocities. Making no allowance for electro-endosmosis, it was confirmed that differences sufficiently large to give hope of separation could not be obtained using clays saturated with the monovalent ions Na^+ , K^+ , NH_4^+ or H^+ (all clays were given a preliminary electro dialysis to remove excess salts and were then, at least partially, H-saturated), although there were indications that saturation with divalent ions, such as Ca^{++} , offered greater possibilities. Further investigations along these lines are in progress. To avoid contamination of the suspensions with excess salt (thus lowering the effective e.m.f. across a cell), all saturations were performed by means of ion-exchange resins.

A paper dealing with theoretical aspects of the hydration of montmorillonite has been published⁶.

SPECTROCHEMISTRY

The past year has been marked by a further increase in the diversity of the methods in use. During the initial period of the development of spectrographic methods applicable to the analysis of soil and plants, covering the years from 1935 until 1947, the only methods employed in the Department were the Lundegårdh flame emission technique (for the determination of alkali and alkaline earth metals in above-trace amounts) and the cathode layer direct current arc method (for the determination of trace elements in soils and plant materials). These methods are still in use, and have adequately demonstrated the ability of spectrographic methods to provide reliable analysis of soils, plants and related materials. The development of electronic techniques has, however, led in the last few years to the introduction of quicker and more efficient methods for certain specific purposes, such as flame photometry for the determination of potassium, sodium and calcium, and triggered alternating current arc emission for zinc and other volatile constituents. This development of methods has been further facilitated recently by the precision workshop which has been able to provide numerous items of equipment of new or improved design.

Liaison with other workers on spectrochemical methods and their applications to agricultural research has been maintained through the meetings of the Consultative Committee for the Development of Spectrographic Work, sponsored by the Department of Agriculture for Scotland, but also embracing workers from Northern Ireland, as well as through the Spectrographic Discussion Group in Glasgow, the Interservices-D.S.I.R. Panel for Emission Spectroscopy, and other groups. The Institute will be represented on the Agricultural Research Council Group for Mineral Deficiencies and Excesses in Animals.

The demands on the Department for training in spectrochemical methods have continued to be embarrassing in their number. Post-graduate workers from Argentina, Egypt, Spain, Australia, Canada, India and Trinidad have spent periods of study in the laboratory, and there have been numerous short term visitors.

A brief account of the work of the Department, presented to the International Microchemical Congress at Graz in 1950, has been published⁷. A revised version of Professor Lundegårdh's monograph on Leaf Analysis, which deals in some detail with flame emission methods of determination, has been translated and published⁸.

FLAME EMISSION METHODS

The flame photometer described in earlier reports has been in continuous use for the determination of potassium, calcium and sodium in extracts of plants and soils. It has proved reliable in operation and required little electronic maintenance. Some 8600 samples have been dealt with during the year, chiefly from the Departments of Soil Fertility, Plant Physiology and

Pedology. This number is considerably below the capacity of the equipment. When determinations of other elements, particularly magnesium and manganese, are required in the extracts, the original Lundegårdh flame technique is employed, and this has been the case with about 3000 samples. This method is considerably slower, and as it necessitates prior concentration of soil extracts, investigations have been initiated into the possibility of employing some more sensitive method; the spark technique discussed below appears promising. The application of interference filters to flame photometry is being investigated, and to facilitate this work, a third flame unit is being produced in the workshop.

ARC EMISSION METHODS

The combination of the direct current cathode layer arc source with chemical concentration by organic reagents has provided a versatile method covering many of the trace elements of biological importance. The elements which can normally be determined in soil or plant materials by these methods, directly or after concentration, include cobalt, nickel, molybdenum, tin, lead, zinc, copper, manganese, titanium, vanadium, chromium, silver, iron, barium and strontium. The possible inclusion of other elements is being studied. A reliable method for the determination of the *available* copper in soils is one of the more complex problems being investigated.

Work has continued on the application of pulsed, that is triggered alternating current, arcs to the determination of zinc and other volatile constituents in powder samples. A tentative method for zinc in plant ash, using cadmium as internal standard, and a line breadth method of photometry, detects as little as 3 p.p.m. zinc.

A step sector on a stand which allows of its adjustment independently of the lens carried on the same stand has been designed and constructed. Modifications to the lathe, involving the tailstock, drive, and cutting equipment have led to faster and more accurate production of carbon electrodes, with fewer breakages. The demand for these is of the order of 12,000 pieces annually, of several different shapes, and, in view of the increasing cost and scarcity of suitable carbon rods, economy in their production is essential. Carbon electrodes are more difficult to machine than the graphite electrodes employed by many spectroscopists, but found unsuitable in this Department for the direct current arc technique.

A description of the method employed for the determination of copper, barium, strontium, manganese, and other elements in plant ash has been published⁹.

SPARK EMISSION METHODS

Spark emission had not hitherto been found applicable to the problems encountered, but preliminary results suggest that a modification of a porous cup technique using spark excitation may be suitable for the determination of magnesium in soil and plant extracts. A spring-loaded clamp to carry the electrodes required in this method has been designed and constructed in the workshop, and a description submitted for publication²⁶.

PHOTOMETRY

It is the practice in the Department to evaluate spectral line intensity by determining blackening curve separation at a specific photographic density. This involves the conversion (Ann. Rep., 1942-43 Appendix B) of microphotometer readings of galvanometer deflections (i) to logarithmic ratios ($\log i_0/i$) followed by the plotting of 3 points to provide a reliable blackening curve. The so-called Seidel transformation, which involves the plotting of $\log (i_0/i - 1)$ rather than $\log i_0/i$ against the logarithm of the relative exposure, results in approximately parallel straight lines being obtained, and it may prove necessary to read only two steps instead of three to obtain the requisite accuracy, but adequate information regarding this point is not yet available. The transformed blackening curve separation is obtained in the usual manner, and should give the same value as the original method.

Values of $\log (i_0/i - 1)$ for $i_0 = 50$ and $i =$ values up to 50 can be tabulated, or a drawing board with a vertical scale on a sliding perspex set-square for the direct conversion of galvanometer readings to these values can be employed. The value of $\log (i_0/i - 1)$ can be found from Appendix B of Ann. Rep., 1942-43 and Appendix C of Ann. Rep., 1943-44 by obtaining $\log i_0/i$ corresponding to the galvanometer reading i and entering the $(\delta - \gamma)$ table with this. The value obtained in the table is then $\log (i_0/i - 1)$.

Correction for spectral background can be carried out exactly as with the earlier method (Ann. Rep., 1943-44, Appendix C), or the $(\delta - \gamma)$ values can be read directly from an appropriately divided scale.

The new method appears to possess advantages of speed and simplicity, particularly if graphical calculating boards of adequate reliability for routine work can be produced. Results so far show good agreement between the two methods, and suggest that the new methods may be somewhat less liable to subjective errors, because of the greater degree of reproducibility of straight lines compared with the tooed blackening curves. The method has however not yet been adopted for routine use.

The advantages for certain purposes of a wavelength:density chart such as is provided by a recording microphotometer have been noted by numerous workers, who have pointed out the difficulties of measuring very weak lines, or lines appearing as a shoulder on a stronger, adjacent line. The slowness for this purpose of the standard type of pen-recording instrument has resulted in the development of mechanically scanned photometers with cathode ray display. A display microphotometer with electronic scanning, eliminating all mechanical movement of the plate and employing an image converter followed by a photomultiplier tube for this purpose, is being developed in the Department, and preliminary results appear promising.

TRACE CONSTITUENTS IN SOILS, PLANTS AND BIOLOGICAL MATERIALS

An account of the geochemical distribution of trace elements in the rocks of the Skaergaard Intrusion, East Greenland, has been published¹⁰ in collaboration with Professor L. R. Wager of the University of Oxford. This basic igneous intrusion is strongly differentiated, with rocks varying in composition from ultra-basic to acidic, and the analyses of the rocks and their constituent minerals have provided important information of wide general application

on the occurrence of trace elements. The study of the changes in trace element solubility during soil formation, as displayed in a series of soil profile investigations, is nearing completion, and will be presented as a doctorate thesis by one of our visiting research workers. The text of a lecture given in 1947 on trace elements in soils and their uptake by plants has been published.¹¹

Collaboration with other departments within the Institute has included the comprehensive examination of bracken samples and the determination of nickel in a considerable number of soil extracts and plant materials for the Department of Plant Physiology. Determinations of cobalt, molybdenum, copper and other trace elements have been made on numerous samples of plant materials and soils from areas where animal disorders are suspected to be due to abnormal trace element contents, and the possibility of cobalt or copper deficiency or molybdenum excess has been noted in several instances. Very low contents of copper and manganese have been found in crops from machair lands in N.W. Scotland. These investigations are carried out in collaboration with the Department of Soil Fertility. A few peat profiles have been examined for the Department of Soil Organic Matter.

The Animal Diseases Research Association has continued to supply samples of animal organs for analysis, and various types of samples from the Hannah Dairy Research Institute, the Rowett Research Institute, and the Torry Research Station have been examined.

Enquiries from National Agricultural Advisory Service sources in England and Wales have included several from areas where excesses of zinc, copper and lead appear to be affecting plant growth. Samples of composts, seaweed meals and fertilizers such as Chilean nitrate have been among the miscellaneous materials examined. From overseas, analyses have included those of samples of rubber leaves on behalf of the Rubber Research Institute of Malaya, soils and herbages from the south of Ireland where unusual animal disorders are reported, and grasses, animal organs and bore-hole waters from Kenya.

ABSORPTION SPECTROMETRY OF SOIL ORGANIC MATTER

The question of the occurrence and nature of the lignin in sphagnum has been further investigated. The usual lignin reactions are obscured by the formation under acid conditions of furfuraldehydes and dark polymerization products from the readily hydrolysable carbohydrates present in sphagnum (60 per cent. of sphagnum is converted into soluble products by ethanolysis). The presence of phenolic ketones can, however, be distinguished among the ethanolysis products and it has been shown that these cannot arise from carbohydrates under the experimental conditions. The nature of the phenolic nucleus present is being investigated.

Preliminary work on the changes in birch lignin produced by wood-rotting fungi has commenced, in collaboration with the Microbiology Section.

A simple technique has been developed for the estimation of scattered light in a photoelectric spectrophotometer, using a 0.2 per cent. solution of sodium hydroxide as the filtering medium. The transmission of such a solution falls rapidly to zero between 220 and 210 m. μ ., and thus the apparent transmission between 210 and 200 m. μ . gives a measure of the scattering in this region within the instrument.

SOIL ORGANIC MATTER

CHEMICAL INVESTIGATIONS

Carbohydrates. The unknown sugars obtained from the soluble carbohydrate fraction of the soil have been separated on a cellulose column and small amounts obtained relatively free from contaminants. Colour reactions on the paper chromatogram were similar to those shown by methylated sugars (Hough, Jones & Wadman, *J. Chem. Soc.*, 1702, 1950) and micro-methoxyl determinations on the fractions gave values approximating to that required by a monomethyl hexose. Demethylation with hydrobromic acid and examination of the products by paper chromatography (Hough *et al*, *loc. cit.*) indicated that the parent sugars were aldohexoses, probably glucose and galactose. In this connection, it has been pointed out (Bayly, Bourne & Stacey, *Nature*, 168, 510, 1951) that the indications of identity obtained by paper chromatography require confirmation, for example by determination of the physical constants of crystalline specimens, and this is now being done. The methylated hexoses were found in eight out of nine soils examined. A soil rich in organic matter (6.4 per cent. C, 4.5 per cent. H₂O) contained approximately 0.006 per cent. of these substances. The discovery of unknown methylated hexoses in soil is of interest in that comparatively few methylated carbohydrates occur in nature (Hirst, Hough & Jones, *J. Chem. Soc.*, 323, 1951) and so a wider distribution is indicated than was hitherto thought likely. In view of the difficulty of preparing these "trace carbohydrates" from soil, further progress will probably be slow, and a preliminary publication is now being prepared.

Work on the carbohydrate metabolism of various fungi has been continued in collaboration with the Microbiological Section. Investigation of the "fungus cellulose" of *Polyporus betulinus* fructification by the classical technique of methylation followed by hydrolysis and separation of the products by the newer chromatographic methods has shown the presence of 1 : 3 linked anhydro-glucose residues. The optical rotation of the methylated product indicates the presence of a proportion of α linkages in contrast to β linkages present in previously known 1 : 3 glucosans such as laminarin and yeast glucan. The yield of crystalline 2 : 4 : 6 trimethylglucopyranose from the methylated material was poor and the presence of modes of linkage other than the α -1 : 3 type cannot be excluded without further investigation.

Nitrogenous Compounds. The study of the amino-acid content of soils has continued and improvements in technique have resulted in the better separation of the amino-acids on paper chromatograms. Progress has been made in placing the investigations on a quantitative basis.

A new naturally occurring amino-acid has been isolated and identified as L-piperidine-2-carboxylic acid (pipecolic acid). This substance, which was first prepared synthetically by Mende in 1896, was detected as an unidentified ninhydrin-reacting substance in paper chromatograms of extracts of the leaves of white clover (*Trifolium repens*) which were being examined for

amino-acids on behalf of Mrs Oxford, Agricultural Research Council Microbiological Unit, University of Aberdeen, in her studies of actinomycetes in relation to composting. It was subsequently found in the acid hydrolysate of a moist woodland soil having *Allium* and *Anemone* as the dominant ground vegetation. Pipecolinic acid has been detected in a number of other plants, notably the *Leguminosae*; of some 30 plants selected from a range of representative genera in just under a half no pipecolinic acid could be detected, while those in which it was found included besides all the *Leguminosae* (*Trifolium*, *Lathyrus*, *Laburnum*, *Vicia*), *Rosa*, *Petasites*, *Nicotiana*, *Urtica*, *Allium* and *Agrostis*. There is at present no evidence that this amino-acid is a constituent of protein; it occurs free in the plant and no suggestion can at present be made as to its origin or function. A preliminary communication on this work has been made to the Biochemical Society²⁷.

The Humus Complex. The action of oxidizing agents on humic acid is being studied and an attempt made to characterize its oxidative degradation products in the hope that these may yield some information bearing on the constitution of this substance.

Further work on humus is being carried on in conjunction with the Department of Spectrochemistry and the Microbiological Section and is discussed in the appropriate sections of the report.

MICROBIOLOGICAL INVESTIGATIONS

Rhizosphere Work. In this work the aim has been to follow the development of the soil microflora during the progress of succession from the colonization of open ground by flowering plants to a relatively complex community. For this purpose a sequence of communities representing the course of succession on sand dunes has been selected. Special attention has been given to the demonstration and analysis of rhizosphere flora associated with colonizing species and with successive dominants of early stages in the succession. The following points have been established.

(1) From dune systems near Newburgh, Aberdeenshire and Tentsmuir, Fifeshire, sets of samples were taken along transects passing inland from the bare sand above high-water mark. Bacterial and fungal populations showed a marked increase with the start of plant colonization. Numbers rose steadily with the development of the vegetation and increasing complexity of the plant community. The colonization of dune grassland by heather, however, was accompanied by a fall in bacterial numbers, although the fungal population continued to rise in dune heath and in a pine plantation on this.

(2) Rhizosphere floras were demonstrated round the root systems of three species colonizing the shore just above highwater mark, namely *Atriplex babingtonii*, *Agropyron junceum* and *Ammophila arenaria*, the last two of which became the dominants of later stages in the succession. The numbers of organisms obtained from the rhizosphere sand were much larger than those from bare sand just above high-water mark.

(3) The organisms obtained by the usual methods of isolating the "rhizosphere" flora include both those from the root surface as well as of the rhizosphere proper, together referred to as the "root region" (Harley, *Biol. Rev.*, 23, 127, 1948). A technique was developed for separating these two floras. Using this technique, and calculating numbers of organisms per unit

weight of substratum, the numbers of organisms from the root surface of *Agropyron* and *Ammophila* were found to be much larger than those from the rhizosphere sand—indicating a denser flora on the root surface.

(4) Morphological investigation of isolates from these two sources (root surface and rhizosphere sand) indicate a high proportion of organisms having affinities with *Corynebacteria*, *Mycobacteria* and *Nocardia*. The flora from the root surface of *Ammophila* differed from that of *Agropyron* in that it carried a greater proportion of gram-negative non-sporing rods. Fungal floras were relatively uniform with a species of *Cephalosporium* predominant, especially in the case of *Ammophila*. A paper on this work has been accepted for publication²⁸.

General. Certain species of the genus *Proactinomyces* (= *Nocardia*, Bergey, 6th ed.) of the group of organisms found to be dominant in the rhizosphere micro-community are able to grow on a liquid paraffin and paraffin wax as sole source of carbon. A strain of one of these species *P. opacus* is being investigated in detail using the Warburg apparatus. A preliminary paper embodying some interesting results has been submitted for publication²⁹.

Mycology. The principal subject of interest has been the degradation of the lignin present in plant tissues. The first line of approach was the direct attack on wood meal by pure cultures of recognized "white rot" fungi. Extracts of the wood before and after attack were prepared by ethanolysis for spectrometric investigation. Pure cultures of timber-rotting fungi were supplied with polyphenolic compounds associated with the degradation of lignin. These substances tend to be toxic and the organisms used do not appear to be able to utilize them as the sole source of carbon. It seems that study of the polyphenol oxidase enzymes present in the white-rot fungi may prove fruitful. These enzyme systems, absent in the cellulose rots, have been found in a number of soil fungi not generally associated with timber decay. Several mucilages produced by hymenomycetous fungi are being examined for their carbohydrate constituents.

FORESTRY INVESTIGATIONS

A paper on work carried out on the Culbin Forest has been published,¹³ and a similar paper on work in the Tentsmuir area has been accepted for publication³⁰.

Culbin Forest continues to be the main research area for the study of profile development in forest soils. The scope of the work, started in 1947, has been extended by the establishment of a number of new sample plots in the older plantations of Corsican pine, and on areas of dune bearing respectively Scots pine, birch and dry heath vegetation.

Samples have been taken from all these plots to a depth of 5 feet for chemical and mechanical analyses. Preliminary analyses of the total iron and aluminium content of some of these samples suggest that leaching is taking place to a considerably greater depth than would appear from the visual examination of the profiles. The degree of leaching varies considerably, depending on the vegetational cover. Since the silt and clay content of the Culbin sand is extremely small, it is possible that the usual grades of particle

size are too wide to give a good indication of particle size distribution. For this reason mechanical analysis has so far been confined to the sub-division of the coarse and fine sand by dry sieving.

In order to investigate further the cyclic movement of available nutrients taking place in the planted areas, the litter fall on the sample plots is being collected at bi-monthly intervals and its nutrient content determined. An attempt is being made to obtain a more continuous record of moisture movements in the soil than is possible by periodic sampling. For this purpose a number of Bouyoucos gypsum moisture blocks have been constructed and buried in the plots. Preliminary readings show that the blocks are well suited to the range of moisture content involved. A parallel study of temperature fluctuations is being made using thermistor units adapted as soil thermometers.

At the request of the Forestry Commission and in collaboration with the Soil Survey Section, data were obtained regarding the soils of the Bowmont Norway spruce sample plots, and were discussed at the British Association field meeting at the Forest. Effects on the soil of different degrees of thinning are not yet generally apparent but considerable differences were found in the rates of nitrification in soils from the various plots. These data have been incorporated in a more general study of nitrogen transformations in forest soil using the percolation technique of Lees (*Plant and Soil*, 1, 221-239, 1949).

PEAT INVESTIGATIONS

Pollen Analyses. These have been carried out on profiles from several mosses near Aberdeen and from Flanders Moss, and profiles sampled from a wider area in the north of Scotland. This work has not yet reached a stage at which generalizations can safely be made. Samples from some of these mosses have also been taken for the spectrochemical determination of trace constituents.

Routine Work. Routine work has continued in connection with the peat survey carried out by the Peat Division of the Department of Agriculture for Scotland. During the year 754 routine samples have been examined and analysed, in addition to some 100 samples submitted for special analysis. The vegetation of the mosses of Altnabreac and Badenloch has been examined and peat samples taken. The samples of ash obtained during analysis are being examined for radioactivity.

A small number of horticultural peats have been submitted for analysis and advice, and the usual number of queries have been answered.

FIELD AND GLASSHOUSE EXPERIMENTAL WORK

This has continued along the same lines as reported last year. More extended experiments involving the use of composts have been established in the field. These will be of a continuous character involving the characterization of the humus produced by the different organic treatments.

PLANT PHYSIOLOGY

The work of the Department has dealt mainly with the examination of ion relationships in nutrient absorption using soil, sand and water culture methods. Investigations have included studies on trace-element toxicities, magnesium-potassium antagonism, iron and manganese nutrition in water-culture, and soft-fruit nutrition. Chemical methods of analysis have also received attention.

Instruction in the methods used in the Department has been given to several visiting research workers, one of whom has collaborated in the research on nickel toxicity.

TRACE ELEMENT TOXICITIES

(a) *Nickel*. In localized areas of Aberdeenshire, the soils are derived from serpentine and contain relatively large amounts of extractable nickel and other trace elements. Under certain conditions, some crops grown in these areas are seriously affected, characteristic symptoms being developed. These symptoms are also produced in sand-culture when the nutrient solution contains 2.5 p.p.m. nickel as nickel sulphate; the soil toxicity, therefore, may reasonably be assumed to be due to nickel. In the oat, which is a convenient indicator plant, symptoms range from a slight chlorosis of the leaf to a prominent longitudinal striping in which extensive leaf areas are colourless.

Sand-culture has been used to examine (1) the effect of nickel on major-nutrient absorption and (2) the relationship between major-nutrient supply (both low and high level) and nickel absorption and toxicity; examination of the data is at present incomplete but indicates that deficiencies of nitrogen, potassium, calcium and magnesium intensify the toxic action of nickel whilst a high level of calcium reduces it. Nickel absorption is being studied at pH values ranging from 4.0 to 7.5 using water-culture. The effects of excessive amounts of other trace elements (aluminium, chromium, cobalt, copper, manganese, molybdenum and zinc) and their interaction with nickel are being examined and the work has shown that of these elements only cobalt produces symptoms similar to those of nickel. The relationship between nickel and iron in deficient and normal amounts is being investigated, results indicating that an adequate supply of iron prevents the development of chlorosis, but not of the more extreme symptoms produced by nickel. Field trials and pot experiments with soil, and sand-culture experiments, are being used to determine the relative susceptibility of common crops to damage by nickel and the most satisfactory soil corrective treatment; the experiments so far have shown cereals (especially oats) to be the most susceptible crops, and improvement of the soil nutrient status (particularly calcium) the most satisfactory remedy. Aberdeenshire and American serpentine soils are being compared from chemical and general fertility aspects and as the investigation proceeds, the number of soils of this type under examination is expected to increase. The effect of

nickel on the carbohydrate content of oat plants has been investigated with the co-operation of the Department of Soil Organic Matter and found to be negligible. The nickel-nitrogen relationship is now being examined. The anatomical changes produced on oat plants by nickel have been studied and the investigation is being extended to a comparison of nickel and cobalt toxicities and iron deficiency; the Department of Botany, University of Aberdeen, is providing facilities for this aspect of the investigation.

(b) *Boron*. A limited investigation followed the occurrence in the field of an abnormally high phosphorus content in oat plants which had received excessive boron. Both soil and sand-culture experiments failed to relate phosphorus uptake to boron supply.

MAGNESIUM-POTASSIUM ANTAGONISM

A preliminary experiment using water-culture was set up to examine the effects of various levels of nitrate, phosphate, chloride and sulphate ions on the uptake of magnesium by tomatoes grown in solutions of equal osmotic pressure and constant potassium/magnesium ratio. The investigation is continuing.

IRON AND MANGANESE NUTRITION IN WATER-CULTURE

Iron as ferric citrate and ferric potassium ethylenediamine tetra-acetate (L. Jacobson; *Plant Physiol.*, **26**, 411, 1951) and manganese as manganese sulphate, were used in a series of nutrient solutions of varying iron and manganese concentration to investigate the effect of concentration and form of iron and concentration of manganese on growth of tomato plants in water-culture. 2.5—5 p.p.m. iron and 0.5—1 p.p.m. manganese gave excellent results when the source of iron was the tetra-acetate complex, the nutrient solution being renewed at intervals of 10 days.

SOFT-FRUIT NUTRITION

The first-year yield data for fruit-bud and fruit production in the raspberry and strawberry experiments have been examined statistically with no significant results. The results confirm that plot size and soil uniformity are adequate. Treatments included factorial combinations of nitrogenous, phosphatic and potassic fertilizers at two levels, the lower being applied in spring and the higher as complete dressings in spring and as split dressings in spring and late summer. The experiments were designed to correlate leaf composition with treatment and with vegetative, fruit-bud and fruit yields.

CHEMICAL METHODS OF ANALYSIS

The analytical technique for diagnosing the nutrient status of plants has been used extensively in the above investigations. Analytical methods have been kept under review; the method for determining potassium has been considerably improved and a rapid method developed for determining calcium which is more sensitive and less susceptible to error from iron, manganese and aluminium interference than the previous one.

RADIOACTIVE STUDIES

The radioactive-tracer investigations outlined in the previous report have been continued.

With the co-operation of the Department of Agriculture, University of Oxford, and the Atomic Energy Research Establishment, Harwell, a radio-autograph technique was applied to determine the distribution of nickel in oat and barley plants affected by nickel toxicity; the results were unsatisfactory, due to the short half-life and low activity of ^{65}Ni . Because of the similarity between nickel and cobalt toxicity symptoms, the investigation is being continued using ^{60}Co which is a convenient isotope for radioactive-tracer studies.

The study of phosphate fixation has been continued in collaboration with the Department of Soil Fertility. In laboratory experiments ^{32}P has been employed to follow the rate of reaction between phosphate and different soils and to study the nature of the reactions taking place. This method has also enabled the total readily exchangeable P in the soils to be measured as a criterion of their phosphate status. The ^{32}P tracer technique has been used in an extensive pot experiment to measure the uptake of applied phosphate by oats from four different soil types and to assess the amount of available phosphate. An attempt has been made to develop a photographic method suitable for following the diffusion of phosphate from fertilizer granules into soils.

Further samples of peat ash, obtained in the course of the Peat Survey of Scotland, have given negative results when tested to determine whether radioactive minerals occur in proximity to the peat moss.

SOIL FERTILITY—CHEMISTRY AND FIELD EXPERIMENTATION

The general object of the work of the Department continues to be the maintenance and improvement of soil fertility in its widest sense of improving both the yield and the feeding quality of crops. To this end experimental work has been continued both on problems with immediate practical implications and on those of the more fundamental type with no obvious immediate bearing on practical agriculture. Throughout these studies of the soil from numerous aspects the aim has been to maintain an appropriate balance between the fundamental and the applied sides. Detailed characterization of field behaviour under varying manuring, seasonal conditions, cropping and management is indispensable to the identification and assessment of the various factors determining the inherent fertility of different soil types. Such data are also necessary as a yardstick for assessing the results of pot experiments and laboratory studies; all three types of work have therefore been continued and extended.

Accounts of the work and reviews of the position to date have been given in the form of addresses to various bodies in different parts of the country and in four publications ^{14, 15, 16, 17}. A paper on the agricultural land resources of Scotland was read at the British Association meeting in Edinburgh.

FIELD EXPERIMENTS

In design these all conform to modern statistical requirements and, depending on the individual objectives, include randomized blocks, latin squares, split plot latin squares, factorial arrangements and lattice squares. The actual statistical work continues to be carried out in the Statistics Department in the University of Aberdeen and we are indebted to Mr M. H. Quenouille and his staff for facilities and willing collaboration. The experiments, which have been continued from previous years or commenced during the past year, are designed to investigate the following main points:

General manuring and liming problems.

Factorial experiments to determine the response of various crops to nitrogen, phosphate and potash in the presence and absence of dung have been continued and extended. Results to date for turnips, swedes and potatoes indicate that the application of dung does not materially reduce the need for nitrogen but it does reduce responses to both phosphate and potash. Experiments have been undertaken to obtain more information on the optimum time of application of nitrogen to cereals, and work is also in hand to find the cause of blind or empty ears in oats growing on certain moderately acid soils. The long-term liming experiments commenced in 1944 to measure the residual effects of various liming materials have been continued. On oats and potatoes in 1950 the differences between the various treatments were scarcely significant. A special study is being made

of the effects of ordinary ground limestone and ground magnesian limestone on the composition of pasture throughout the growing season; the magnesian limestone has the effect of increasing appreciably the magnesium content of the herbage.

As emphasized in previous reports one of the major objects of the field experiment work is the characterization of the yielding capacity and nutrient status of the principal soil associations identified in the Soil Survey of Scotland. Most of the experiments make some contribution to this end and, in addition, a more specific contribution continues to be made by the soil substitution experiments at Craigiebuckler and by the corresponding set of experiments on farms from which the soils were taken. Both these sets of long-term experiments are now at the pasture stage in the first rotation.

Phosphate relationships of soils

(1) *Effectiveness and positional availability of phosphate residues.* New experiments on the Countesswells, Inch, Foudland and Stonehaven Soil Associations have been started. In these the residual effects of dressings of up to 960 lb. P_2O_5 per acre applied for oats in 1951 will be estimated in terms of fresh dressings applied to roots in 1952. The 1951 treatments include applications before and after ploughing to study the effect of the factor of positional availability on the effectiveness of the residues, and hence to clarify the relationship between field estimates of availability and laboratory measurements of solubility. The effect of lime on phosphate availability is also being tested in these experiments.

(2) *Time of application of phosphate.* The effect of varying periods of contact between superphosphate and bare soil under field conditions is being tested in a new series of experiments with particular reference to phosphate at low rates of application. This question is of considerable theoretical as well as practical importance, and to obtain adequate information experiments will have to be continued over a number of seasons.

(3) *Forms of phosphate.* Trials with dung-superphosphate mixtures and superphosphate of varying particle size have been continued and two co-operative experiments have been started to test the effectiveness of "Nitrophosphate." This type of experiment is being continued with different crops over a number of seasons until adequate data are available.

(4) *Comparison of well-drained and poorly-drained soils.* Experiments involving lime, sulphur and phosphate treatments are in progress on corresponding well-drained and poorly-drained soils to investigate the significance of the marked contrasts in their phosphate relationships which are found in laboratory studies.

(5) *Penetration of phosphate in grassland.* The long-term experiment commenced two years ago is being continued.

A paper on the efficient utilization of phosphate fertilizers and summarizing the practical conclusions to be drawn from the work to-date has been accepted for publication³¹. The main topics dealt with are: amount, frequency, time and method of application, the effectiveness of different forms, and the effects of soil conditions. The broad conclusion is that each crop should receive a dressing according to its responsiveness and the degree of deficiency in the soil,

and that no attempt should be made to build up large reserves quickly by the application of single heavy dressings. Suitable placement and adequate liming are also of prime importance. Under Scottish conditions citric-soluble forms of phosphate provide very effective alternatives to superphosphate.

Fertilizer Placement

The investigations on placing fertilizers for turnips and swedes grown in ridges referred to in previous reports have been continued, and a report on the 1950 experiments has been submitted to the Agricultural Research Council. So far, the results indicate that with superphosphate placement in a band $1\frac{1}{2}$ to $2\frac{1}{2}$ inches below the seed is likely to be more effective than either broadcast application or placement in bands in other positions relative to the seed. With sulphate of ammonia and muriate of potash there does not appear to be any particular advantage or disadvantage in band placement, but further work with individual fertilizers and with mixtures is required before definite conclusions can be drawn.

A general account of the results obtained and of their practical implications has been given in a paper dealing with factors affecting methods of applying fertilizers which has been accepted for publication³². The question of when, where and how fertilizers should be applied are discussed, and it is emphasized that in Scotland at present the case for placement hinges mainly on the cereal crop, with which the combine-drilling of superphosphate or mixtures containing phosphate gives better yields than customary broadcast application. A paper giving the results of earlier experiments, referred to in previous reports, has now been published¹⁸.

POT EXPERIMENTS

An additional 130 pots of the Mitscherlich type have been obtained and pot experimental work has been continued and extended to supplement the field data and to investigate specific problems such as the effect of neutral salts on phosphate availability. An experiment covering three pairs of corresponding well-drained and poorly-drained soils and four sources of phosphate has been carried out to test the effect on availability to plants of phosphate left in contact with moist soil for six months. A parallel experiment with cropped and uncropped soils has also been started to give in 1952 a measure of the effect of one year's contact between phosphate and soil, and to study the influence of the roots of growing crops on the reactions between the added phosphate and the soil.

In collaboration with the section for Radioactive Studies, the ^{32}P tracer technique has been applied to estimate the uptake of added phosphate from different soil types, and to measure the amount of available phosphate in the soils for comparison with values obtained by chemical extraction.

LABORATORY WORK

Extensive analytical work has been continued on soil and produce samples from the various experiment areas in order to characterize the soils as fully as possible and to determine the effects of the experimental treatments on the

mineral composition of the crops. Apart from this the laboratory work has been devoted mainly to various aspects of the phosphate relationships of the soils. The main subjects under investigation are:

Fractionation of phosphate

This covers such determinations as total phosphate, organic phosphate, alkali-soluble, fluoride-soluble and various categories of acid-soluble phosphate. Surface soils from experiment areas are being examined along these lines to study the relationships of the different categories and their bearing on the field behaviour of the soils. Parallel studies are in progress on the distribution of phosphate in soil profiles. These include a series of profiles with contrasting drainage conditions, which are being examined in collaboration with the Soil Survey Section, and profiles corresponding to the soil substitution experiments, the latter forming a special subject of study for a higher degree by one of the Overseas Workers. To supplement these phosphate fractionations various categories of iron and aluminium compounds in the soils are being estimated.

Phosphate retention

Sorption curves obtained from systems of varying pH, dilution and salt concentration are being used to study the mechanism of phosphate retention in different soils. Instructive contrasts have been found between corresponding well-drained and poorly-drained soils, and there appear to be at least four factors involved, viz.: binding by iron, binding by aluminium, a Donnan effect of divalent calcium and, in some cases, precipitation of calcium phosphate. The sorption curves show characteristic variations in form depending on the relative contributions of these factors. It is hoped shortly to prepare an account of this work for publication.

Rate of phosphate fixation

This work is the counterpart of the field and pot experiments on the effect of different periods of contact between phosphates and soils. One approach involves solubility measurements on mixtures of soil and phosphate treated under different conditions in the laboratory and on phosphate residues in samples from field plots. The other main approach is by means of isotopic exchange experiments with ^{32}P in collaboration with the Section on Radio-active Studies.

During his stay at the Institute as a British Council Scholar, Mr Erik Eriksson collaborated in some of the work on phosphate, and prepared a theoretical paper on the significance of physico-chemical measurements in colloidal systems¹⁹. He also read a paper to the British Society of Soil Science on the physico-chemical behaviour of nutrients in soils. In this paper a series of relationships derived from existing data on pH, solubility products, dissociation constants, and oxidation-reduction potentials is presented. From these the probability of formation of various compounds and the order of magnitude of the equilibrium concentrations of different nutrients under varying soil conditions are assessed.

Another overseas worker who has also been collaborating in the phosphate retention studies is Dr L. H. P. Jones, a Nuffield Foundationer from Melbourne University. The latter is also extending his Australian investigations

on *manganese* to Scottish soils, with particular reference to the laboratory assessment of manganese status and the ability of different soils to reduce added manganese oxides.

The paper on the effects of acid treatments on soil phosphate referred to in last year's report has now been published²⁰. Further papers covering work in which Dr Williams took part when he was in Sweden have also now appeared ^{34, 35, 36, 37, 38}.

ADVISORY AND OTHER *AD HOC* WORK

Advisory work on soils in co-operation with the North of Scotland College of Agriculture has been continued, and during the year over 8,000 samples of soil have been tested. Other work includes the determination of the agricultural value of various liming materials and industrial and other by-products. Advisory work on the maintenance and improvement of fertility in forest nursery soils has also been undertaken, mainly on behalf of the Forestry Commission.

The recording of analytical data and the grouping of advisory soil samples from Aberdeenshire and Kincardineshire on the basis of soil associations have also been continued. The main trend is towards deficiencies in lime and phosphate being less marked in the Stonehaven and Laurencekirk Associations and potash deficiency being less pronounced in these two and the Cruden Association than in the others. Although increased quantities of lime and fertilizers have been used in recent years, there are still widespread deficiencies in lime and phosphate and the majority of the soils are slightly low in potash.

Specialist advisory enquiries, with particular reference to the trace element contents of soil and produce in relation to animal health, are becoming steadily more numerous. In collaboration with the Department of Spectrochemistry many reports have been drawn up and, in doubtful cases, *ad hoc* trace element experiments arranged through the veterinary and other specialist services.

COLLABORATIVE WORK

A survey of agricultural, forestry and fishery products and their utilization in the United Kingdom has been carried out jointly with Dr F. N. Woodward and the late J. P. Maxton. A report has been prepared and presented to the Development Commission.

PUBLICATIONS

(A) Published during the year—

1. Recent advances in soil research at the Macaulay Institute. By D. N. McArthur. (*Proc. Roy. Philos. Soc., Glasgow*, **74**, 73-78, 1950).
2. The Macaulay Institute for Soil Research. By D. N. McArthur. (*Brit. Agric. Bull.*, **4**, No. 13, 3-6, 1951).
3. Vermiculite-organic complexes. By G. F. Walker. (*Nature*, **166**, 695, 1950).

Organic complexes of vermiculite, like those of montmorillonite and halloysite, are found to be of two types. Complexes are formed with organic cations, such as codeine, where displacement of the vermiculite basal reflection depends on the concentration and the nature of the amine. Van der Waals adsorption complexes with substances such as glycerol are formed to a limited extent depending on the exchangeable inorganic cation present.

4. Vermiculites and some related mixed-layer minerals. By G. F. Walker. (*X-ray Identification and Crystal Structure of Clay Minerals*, Chap. VII. The Mineralogical Society, London, 1951).

In a handbook on the identification of clay minerals this chapter defines the mineral vermiculite and discusses its chemical, structural, optical, thermal and dehydration criteria. Methods are given of distinguishing between vermiculite, chlorite and montmorillonite and between the pure mineral and the common mixed structures, mica-vermiculites and chlorite-vermiculites. The nature of the interlayer water and the properties which make this mineral important in soils, in structural investigations and, when exfoliated, in building and industry are fully discussed.

5. A micromethod for determination of cation-exchange capacity of clay. By R. C. Mackenzie. (*J. Coll. Sci.*, **6**, 219-222, 1951).

A method is described for the determination of cation-exchange capacities of clays on samples of 10-50 mg. The method is discussed and the results obtained compared with those using the normal method employed here for samples of 0.2-1.0 g. clay.

6. Some notes on the hydration of montmorillonite. By R. C. Mackenzie. (*Clay Min. Bull.*, No. 4, 115-119, 1950).

Present theories of the structure of intersheet water in montmorillonite are discussed and some criticisms presented. Calculations of hydration energies of cations for one or two shells of water molecules show good correlation with the temperature of the hygroscopic moisture peak on thermograms of montmorillonite saturated with these cations, thus indicating that hydration of the sorbed cation may be the most important factor—at least at low water contents.

7. The spectrographic determination of trace elements in rocks, minerals and soils. By R. L. Mitchell. (*Mikrochemie*, **36/37**, 1042-1047, 1951).

The total content of trace elements in rocks, minerals and soils is determined by a semi-quantitative cathode layer arc spectrographic technique. For more accurate determinations a variable internal standard technique, in which the trace element contents are compared with that of iron, is employed. This method is combined with a chemical concentration for the analysis of extracts of soils and plant materials. The chemical concentration technique involves the use of 8-hydroxyquinoline, tannic acid and thionalide, and gives recovery of microgram quantities of most trace elements, rejecting at the same time the alkalis, alkaline earths and phosphate.

8. Leaf analysis: an authorized translation by R. L. Mitchell of "*Die Blattanalyse*" by H. Lundegårdh. (*Hilger & Watts*, 98 St. Pancras Way, London, N.W.1. Price: 22/6 plus postage 6d.).

Describes practical results of using analysis of leaves as a method for the determination of manurial requirements of soil. Spectrographic methods were employed and an automatic, "Robot" equipment specially designed to deal with the vast number of solutions investigated, is described. Of interest to investigators in plant physiology or applied botany as well as practising spectroscopists.

9. The spectrographic analysis of plant ash in the carbon arc. By V. C. Farmer. (*Spectrochim. Acta*, **4**, 224-228, 1950).

A spectrographic method using the cathode layer arc technique for the determination of Cu, Fe, Mn, Sr, Ba, Na, Mg and Ca in plant ashes without chemical pre-treatment is reported. Potassium sulphate is used as a spectrographic buffer, while traces of Ag and Cr incorporated in the carbon powder provide internal standards for the elements determined. A method for preparing CaCO_3 free from Sr and Ba is reported.

10. The distribution of trace elements during strong fractionation of basic magma — a further study of the Skaergaard intrusion, East Greenland. By L. R. Wager (*University of Oxford*) and R. L. Mitchell. (*Geochim. Acta*, **1**, 129-208, 1951).

A number of trace elements have been determined spectrographically in the rocks and minerals of the Skaergaard intrusion, East Greenland. The original basic magma from which the varied rocks of the complex were developed is shown to have had a normal trace element composition. The sorting out of the trace elements into the various mineral series produced by strong fractional crystallization of the original basic magma is traced in detail by means of analyses of the separated minerals. Certain of the trace elements (Cr, Ni) are shown to be strongly concentrated in the early rocks so that later fractions have little or none of them; other elements (P, V, Cu, Sc, Mn, S) reach maximum values in the middle or late middle stages represented by certain olivine-free gabbros and ferrogabbros; other elements (Li, Zr, Y, La, Ba, Rb) tend to remain in the residual liquid during fractionation and are thus abundant in the latest granite fraction. Still other trace elements (Co, Sr, Ga, Mo) show only small changes in amount throughout the series. Of these Co is a little more abundant in the early and middle stages, Sr in the middle stages, Ga in the later stages and Mo in the early and later but not in the middle stages. The distribution of the trace elements in the rocks is considered in relation to the varying composition of the minerals produced by the fractional crystallization process and an attempt is made to discuss the mineral compositions in terms of crystal chemical concepts.

The Skaergaard sequence by differentiation from gabbros, through ferrogabbros, to granite is considered to be a common trend of fractionation of basic magma at high levels in the crust, and the observed changes in trace element composition of the intermediate Skaergaard differentiates is significantly different from that of diorites reported by other workers and suggests that diorites have had some other origin than by fractionation of basic magma. On the other hand the trace element composition of many granites resembles that of the granite fraction produced in the Skaergaard intrusion.

11. The trace constituents of the soil. By R. L. Mitchell. (*Trans. XI. Int. Cong. (1947) Pure and Appl. Chem.*, **3**, 157-164, 1951).

A lecture on the factors involved and their relation to uptake by the plant.

12. Peat and its uses in horticulture. By G. K. Fraser. (*J. Bd. Greenk. Res.*, **7**, 322-334, 1950).

The introductory Part I of this paper deals along conventional lines with the origin and formation of types of peat deposits and the distribution of these in this country. Part II covers the essentially practical side of the utilization of peat under the headings of peat harvesting, the chief types of peat and their uses (with special reference to horticulture) and the reclamation of peat for agriculture and horticulture. These subjects are dealt with in a semi-popular manner.

13. The afforestation of the Culbin Sands. By J. D. Ovington. (*J. Ecol.*, **38**, 303-319, 1950).

Discussion of the ecological changes resulting from the reclamation of the Culbin Sands by the Forestry Commission.

14. Fertilizer utilization with special reference to phosphates. By A. B. Stewart. (*Fert. Soc. Proc. No. 12*, 1950).

The problems of the efficient use of fertilizer phosphorus are discussed under the heads of land utilization and consumption of fertilizers in the U.K., the respective merits of mixtures and of straight fertilizers, general response to fertilizers, field, pot and laboratory studies of the phosphate relationships of soils with special reference to phosphate fixation, the relative effectiveness of phosphate in different forms, placement, liming and other means of increasing the effectiveness of applied phosphate.

15. Fertilizers and lime in Scotland. I. Fertilizers and crop production. By A. B. Stewart. (*Scot. Agric.*, **30**, 107-111, 1950).

A brief review of the principal scientific and technical factors affecting the use of fertilizers, with particular reference to:—land utilization and fertilizer consumption in Scotland, factors affecting the response to fertilizer and estimated annual fertilizer requirements of arable and grassland in Scotland.

16. Fertilizers and lime in Scotland. II. Lime and soil fertility. By A. B. Stewart. (*Scot. Agric.*, **30**, 149-153, 1951).

A stocktaking of the position regarding the use of lime in Scotland, with special reference to:—forms of lime available, tonnage of lime consumed in Scotland during the period 1937-1949, need for more liming and for using supplies to the best advantage, rates and time of application, dangers of over-liming.

17. Fertilizers and crop production. By A. B. Stewart. (*Dept. Agric. Scot. Advis. Leaflet*, No. 18, n.s., 1951).

The principal scientific and technical factors affecting the use of fertilizers are discussed under the heads of:—land utilization, fertilizer units and valuation of fertilizers, consumption of fertilizers in Scotland, factors affecting response to fertilizers, profitability, and estimated annual fertilizer requirements of land under crops and grass in Scotland.

Supplies are still quite inadequate to meet all possible demands, and the case is argued for meeting the fertilizer requirements of arable land, permanent grassland, and other land, in that order of precedence.

18. Placement of mineral nutrients in soils. By A. B. Stewart. (*Trans. XI. Int. Cong. (1947) Pure and Appl. Chem.*, **3**, 301-307, 1951).

An account of the results obtained in the earlier experiments on placement of fertilizers.

19. The significance of pH, ion activities and membrane potentials in colloidal systems. By E. Eriksson. (*Science*, **113**, 418-420, 1951).

Different theories for explaining the potential which arises across an electrically charged colloidal membrane separating two solutions of different salt activities are discussed and compared.

20. Effects of acid treatment of soils on phosphate availability and solubility. By E. G. Williams. (*J. Soil Sci.*, **21**, 110-117, 1951).

Pot tests with oats showed that extraction of soils with 2.5 per cent. (by vol.) acetic acid and 0.007N sulphuric acid, respectively, followed by restoration of the cation content and pH, increased greatly the availability of the remaining phosphate. This more than compensated for the readily soluble phosphate removed, and the treated soils gave much higher yields and P_2O_5 uptakes than the untreated soils. On three of the four soils used, treatment with acetic acid resulted in a considerably greater increase than treatment with sulphuric acid. Solubility measurements in water and in a solution of salts, simulating the basal dressings used in the pot tests, also gave higher values for the treated soils.

The solubility increases run parallel to, and are probably sufficient to account for, the increase in availability. The nature of the effect is discussed and it is attributed to a combination of factors, such as: deactivation of fixing agents, partial hydrolysis of difficultly soluble inorganic and organic phosphates, and redistribution of phosphate in the soils. One of the treated soils showed a marked increase in adsorbed phosphate.

(B) *Submitted for publication—*

21. Effect of grinding on micas. By R. C. Mackenzie and A. A. Milne. (To appear in *Clay Min. Bull.*).
22. Unidimensional Fourier synthesis of vermiculite. By G. F. Walker and A. A. Milne. (To appear in *Clay Min. Bull.*).
23. Differentialthermoanalyse und ihre Anwendung auf technische Stäube. By R. C. Mackenzie. (To appear in *Tonindust. Zeit.*).
24. The trace elements in sea-water and the brown marine algae common to Scotland. By W. A. P. Black (Institute of Seaweed Research) and R. L. Mitchell. (To appear in *J. Mar. Biol. Ass. U.K.*).

25. The administration of cobalt by different routes to lambs maintained on a low cobalt diet. By A. T. Phillipson (Rowett Research Institute) and R. L. Mitchell. (To appear in *Brit. J. Nut.*).
26. Electrode clamps for spectrochemical analysis. By R. O. Scott and A. M. Fraser. (To appear in *Spectrochim. Acta.*).
27. Naturally occurring L-pipecolinic acid. By R. I. Morrison. (To appear in *Proc. Biochem. Soc.* (Biochem. J.))
28. Development of a soil microflora in relation to plant succession of sand dunes, including the "rhizosphere" flora associated with colonizing species. By D. M. Webley, D. J. Eastwood and C. H. Gimingham (University of Aberdeen). (To appear in *J. Ecol.*).
29. The metabolism of some saturated aliphatic hydrocarbons, alcohols and fatty acids by *Proactinomyces opacus* (Jensen)=*Nocardia opaca* (Waxman and Hendrick, Bergey, 6th ed.). By D. M. Webley and P. C. de Kock (University of Aberdeen). (To appear in *Biochem. J.*).
30. Afforestation of Tentsmuir. By J. D. Ovington. (To appear in *J. Ecol.*).
31. Making the best use of phosphate fertilizers. By E. G. Williams. (*Scot. Agric.*, **31**, 68-72, 1951).
32. Factors affecting the methods of applying fertilizers. By J. W. S. Reith. (*Scot. Agric.*, **31**, 104-109, 1951).
33. Soil Survey maps (1 inch to 1 mile) based on Ordnance Survey Sheets 86 and 96 (3rd ed.), and descriptive memoir.

(C) *Collaborative Work (Foreign)*

34. Phosphate relationships of soil and plant. II. Soil—soil solution equilibria and phosphate solubility. By S. Mattson, E. G. Williams, E. Eriksson and K. Vahtras. (*Ann. Roy. Agric. Coll. Sweden*, **17**, 65-91, 1950).
35. Phosphate relationships of soil and plant. III. Forms of P in the Brannalt limed and unlimed podzol series. By S. Mattson, E. G. Williams and E. Barkoff. (*Ann. Roy. Agric. Coll. Sweden*, **17**, 107-120, 1950).
36. Phosphate relationships of soil and plant. IV. Forms of P in the hydrologic soil series of the Dala Brown Earth and the Udden podzol. By S. Mattson, E. Barkoff and E. G. Williams. (*Ann. Roy. Agric. Coll. Sweden*, **17**, 121-129, 1950).
37. Phosphate relationships of soil and plant. V. Forms of P in the Lanna soil. By S. Mattson, E. G. Williams, E. Koutler-Andersson and E. Barkoff. (*Ann. Roy. Agric. Coll. Sweden*, **17**, 130-140, 1950).
38. Boden-Bodenlösungsgleichgewichte und Phosphatlöslichkeit. By S. Mattson, E. G. Williams, E. Eriksson and K. Vahtras. (*Z. PflErnahr. Dung.*, **50(95)**, 39-59, 1950).

APPENDIX

The following are more detailed descriptions of the soils found in the survey areas.

NORTH-EAST SCOTLAND

Morayshire (Geological Survey Sheet 95)

ASSOCIATIONS

FOUDLAND ASSOCIATION

- Distribution* . The higher ground south of Buckie, around Tarrymount.
Parent Material . Till derived from fine-grained flag-stones of the Highland Schists.
Dominant Series . Freely drained.

Profile

<i>Horizon</i>	<i>Depth</i>	
S	0-10 in.	Grey-brown, fine sandy loam; crumb structure. Sharp change into
B ₂	10-18 in.	Yellow-orange, fine sandy loam; soft and mellow; weakly cloddy. Sharp change into
B ₃	18-24 in.	Grey-yellow, sandy loam; indurated. Merging into
C	28 in. +	Yellow, stony fine sandy loam till.

The topography is hilly.

BOYNDIE ASSOCIATION

- Distribution* . Over practically the whole area bounded by a line Portgordon-Fochabers-Elgin-Lossiemouth, except for the Corby and Links areas listed below, and where cut across by the alluvium of the Spey and the Lossie.
Parent Material . Fluvio-glacial sand.
Dominant Series . Freely drained.

Profile

<i>Horizon</i>	<i>Depth</i>	
S	0-10 in.	Grey-brown, loamy sand; soft cloddy structure. Merging into
A ₁	10-16 in.	Transitional; grey-brown sand merging downwards to yellow-brown sand; soft and loose.
B ₂	16-22 in.	Bright yellow-brown sand; single grain structure. Sharp change into
C	22-44 in.	Light-brown sand; single grain structure; moderately compact.

The topography is undulating to hummocky.

STRICHEN ASSOCIATION

<i>Distribution</i>	.	On top of Hillhead Wood and south from Bridge of Shougle.
<i>Parent Material</i>	.	Till derived from quartz schist and mica schist.
<i>Dominant Series</i>	.	Freely drained.

Profile

<i>Horizon</i>	<i>Depth</i>	
S	0-10 in.	Grey-brown sandy loam; crumb structure. Relatively sharp change into
B ₂	10-18 in.	Yellow sandy loam; soft cloddy structure. Sharp change into
B ₃	18-24 in.	Yellow-grey loamy sand; strongly indurated. Merging into
C	24 in. +	Pale yellow, stony sandy loam till.

The topography is hilly.

CORBY ASSOCIATION

<i>Distribution</i>	.	An irregular area west of the Spey between Moss-todloch and Upper Ashfield (a high terrace); in Threapland Wood; in isolated patches throughout the area of the Boyndie Association.
<i>Parent Material</i>	.	Water-sorted and morainic gravel.
<i>Dominant Series</i>	.	Freely drained.

Profile

<i>Horizon</i>	<i>Depth</i>	
A ₀ F	0-3 in.	Dark brown, partially decomposed fibrous organic matter. Sharp change into
A ₂	3-8 in.	Grey gravel with grey-brown interstitial coarse sand. Sharp change into
B ₂	8-11 in.	Orange-brown sandy gravel; compact. Merging with decreasing compaction into
B ₃	11-20 in.	Yellow-brown gravel. Merging into
C	20-40 in.	Pale yellow-brown gravel; tending to single grain structure.

The topography of the larger area is flat; elsewhere it is moundy.

TYNET ASSOCIATION

<i>Distribution</i>	.	An irregular strip 1½ to 2 miles wide, from Fochabers to Inchgower.
<i>Parent Material</i>	.	Till derived from sandstone and conglomerate of the Middle Old Red Sandstone.
<i>Dominant Series</i>	.	Freely drained.

Profile

<i>Horizon</i>	<i>Depth</i>	
S	0-7 in.	Medium brown loam; weak cloddy to crumb structure. Sharp change into
B ₂	7-14 in.	Bright orange-red gravelly sandy clay loam; crumb structure. Sharp change into

B ₃	14-20 in.	Red gravelly clay loam; strongly indurated. Merging into
C	20-40 in.	Red gravelly clay loam till; cloddy structure; compaction decreasing with depth.

The topography is undulating.

LINKS

Distribution . . . In the raised beach strip from Spey Mouth east to Portgordon, and in parts of the corresponding strip westwards from Kingston to Lossiemouth.

The soil is mainly freely drained and has 4-6 inches of dark brown loamy sand with soft cloddy structure over light yellow-brown sand with single grain structure.

The topography is generally flat.

UNDIFFERENTIATED ALLUVIUM

Distribution . . . Wide spreads bordering the Rivers Spey and Lossie, notably at Dipple, Manbeen, Calcots and Bar-muckity.

All textural grades from coarse sand to silt are found in the alluvium and drainage is dominantly poor.

SKELETAL SOILS

DUNE SANDS

Distribution . . . A relatively narrow strip extending eastwards along the coast from Lossiemouth for about four miles.

Parent Material . . . Blown sand.

The area is mainly bare of vegetation and no profile has developed.

STORM BEACH SHINGLE

Distribution . . . A $\frac{1}{4}$ to $\frac{1}{2}$ mile wide strip along the coast from Lossiemouth to Garmouth, behind the sand-dunes where they exist.

Parent Material . . . Shingle of storm beaches of 25 foot raised beach.

Dominant Series . . . Excessively freely drained.

Profile

Horizon	Depth	
A ₀ F	0-1 in.	Very thin layer of felty, partially decomposed organic matter.
C		Grey, well-rounded stones, 1 to 4 inches in diameter, mostly of quartzite and quartz schist; loose.

The topography consists of long, narrow ridges from 4 to 10 feet high with wet spots and small lochans between.

Most of this area has been planted with Scots pine.

Aberdeenshire and Kincardine (Geological Survey Sheet 66)

ASSOCIATIONS

COUNTESWELLS ASSOCIATION

- Distribution* . . . An area north of the Dee valley between the eastern edge of the Moor of Dinnet and Hirn; the hill country south of the Dee from the west boundary to Finzean; and area south of the Dee extending eastwards from Slewdrum to Banchory.
- Parent Material* . . . Till derived from granite and granitic gneiss; sometimes rather water-sorted, as in the area north of the Dee.
- Dominant Series* . . . Freely drained.

Profile

<i>Horizon</i>	<i>Depth</i>	
A ₀ F	0-6 in.	Black raw humus. Sharp change into
A ₂	6-9 in.	Grey organic sandy-loam; white bleached quartz grains and granite fragments; structureless. Sharp change into
B ₂	9-17 in.	Bright orange-brown sandy-loam; crumb structure; some darker brown patches of humus staining. Merging into
B ₃	17-24 in.	Pale grey-brown, gritty, stony, loamy sand drift; indurated; induration decreasing with depth.
	24 in. +	Pink weathered granite.
The profile is often shallower on hill slopes.		
The topography is generally hilly to mountainous.		

CORBY ASSOCIATION

- Distribution* . . . The Moor of Dinnet; gravel terraces and morainic mounds lining the Dee valley and its larger tributaries; remnants of end moraines at valley mouths; in Feughside where the Water of Aven joins the Water of Feugh.
- Parent Material* . . . Fluvio-glacial gravels.
- Dominant Series* . . . Freely drained.

Profile

<i>Horizon</i>	<i>Depth</i>	
A ₁	0-2 in.	Mull humus. (Vegetation—larch wood).
A ₂	2-4 in.	Bleached greyish coarse sand; single grain structure. Merging into
B ₂	4-15 in.	Pale brown, gravelly coarse sand with darker brown patches of organic staining. Merging into
B ₃	15-23 in.	Darker brown loamy sand; rather indurated. Merging into.
C	23 in. +	Brownish gravelly coarse sand; single grain structure.
The topography consists of river terraces and areas of moundy moraine.		

DEECASTLE ASSOCIATION

<i>Distribution</i>	.	Patches along the south side of the Dee valley from Glentanar to Feughside between the river gravels and the granitic till on the hills.
<i>Parent Material</i>	.	Till derived from calc-silicate rocks and schists with a variable proportion of granite and granitic gneiss.
<i>Dominant Series</i>	.	Freely drained.

Profile

<i>Horizon</i>	<i>Depth</i>	
S	0-10 in.	Dark medium brown loam; soft cloddy structure. Sharp change into
B ₂	10-16 in.	Yellow-brown, stony fine sandy-loam; soft cloddy structure. Sharp change into
B ₃	16-25 in.	Yellowish-grey, gritty sandy-loam; indurated.
	25 in. +	Induration decreases with depth.

These soils are found on the lower hill slopes south of the Dee.

SKELETAL SOILS

GRANITE

<i>Distribution</i>	.	Extensive areas of high ground throughout the hill country south of the Dee valley.
<i>Parent Material</i>	.	Weathered granite.

Profile

<i>Horizon</i>	<i>Depth</i>	
A	0/6 in. (variable)	Black raw humus; very gritty; speckled with white quartz.
	6/20 in. (variable or absent)	A scree of coarse granite boulders up to 3 feet in diameter. Interstices filled with organic stained granite gravel.
		Weathered granite.

The topography is mountainous.

HILL PEAT

Limited amounts of saddle peat are found in the same area as the skeletal soils.

EAST SCOTLAND

Angus (Geological Survey Sheet 57)

ASSOCIATIONS

CORBY ASSOCIATION

<i>Distribution</i>	.	Morainic mounds scattered throughout the arable area. Some patches of river terrace along Noran Water.
<i>Parent Material</i>	.	Fluvio-glacial gravel.
<i>Dominant Series</i>	.	Freely drained.

Profile

<i>Horizon</i>	<i>Depth</i>	
S	0-10 in.	Dark brown sandy loam; cloddy crumb structure; many well-rounded stones. Fairly sharp change into
B ₂	10-18 in.	Bright brown, gravelly, gritty loamy-sand; loose, weak crumb structure. Merging into
B ₃	18-26 in.	Dull brownish, gritty, gravelly loamy coarse-sand; strongly indurated. Merging into
C	26 in. +	Brown, gritty, gravelly coarse-sand; single grain structure.

The topography is moundy or flat.

STRICHEN ASSOCIATION

<i>Distribution</i>	.	A triangular area of hill country between Glenquiech, Glen Lethnot and Toardyll.
<i>Parent Material</i>	.	Fine sandy-loam till derived from flaggy quartzite and quartz mica-schist.
<i>Dominant Series</i>	.	Freely drained.

Profile

<i>Horizon</i>	<i>Depth</i>	
A ₀ L	0-½ in.	Calluna-moss litter.
A ₁	½-1 in.	Dark greyish-brown, organic loam; white specks of quartz.
A ₂	1-2 in.	Light greyish-brown, fine sandy-loam; crumb structure; occasional small stones. Merging into
S	2-9 in.	Medium brown, fine sandy-loam; crumb structure; moderate stone content of medium and small stones. Merging into
B ₂	9-19 in.	Brighter orange-brown, stony, fine sandy-loam with patches of darker brown organic staining; crumb structure; large and small subangular stones. Merging into
B ₃	19-36 in.	Pale brown, fine sandy loam; indurated platy to cloddy structure. Merging into
C	36 in. +	Greyish-yellow, stony, fine sandy-loam till.

Profile quoted is an old arable soil now under calluna, at an altitude of c.1200 feet above OD, showing horizons of incipient repodzolisation.

The topography consists of steep elongated ridges, hilly to mountainous.

STONEHAVEN ASSOCIATION

<i>Distribution</i>	.	One small area immediately south of Shandford Hill.
<i>Parent Material</i>	.	Sandy clay loam till derived from Old Red Sandstone sandstones and conglomerate beds.
<i>Dominant Series</i>	.	Poorly drained.

Profile

<i>Horizon</i>	<i>Depth</i>	
S	0-10 in.	Dark brown loam; cloddy structure; moderate stone content. Fairly sharp change into
G	10-36 in.	Reddish-brown sandy clay loam; cloddy prismatic structure; considerable grey and rusty mottling. Merging into
C	36 in. +	Red-brown, stony, sandy clay loam till.

The topography is gently sloping.

STRATHFINELLA ASSOCIATION

<i>Distribution</i>	The Caterthuns, Ledmore Hill, Shandford Hill and a small area at Noranside.
<i>Parent Material</i>	Loam to sandy loam till derived from sandstone and conglomerate beds of Old Red Sandstone age with metamorphic erratics.
<i>Dominant Series</i>	Freely drained.

Profile

<i>Horizon</i>	<i>Depth</i>	
S	0-6 in.	Brown sandy-loam; crumb structure. Sharp change into
B ₁	6-9 in.	Pale reddish-brown sandy-loam; crumb structure. Merging into
B ₂	9-14 in.	Bright brownish-red sandy-loam; crumb structure. Merging into
B ₃	14-27 in.	Pale reddish-brown loam to sandy-loam; strongly indurated; compact cloddy structure. Merging into
C	27 in. +	Light brownish-red, loam till.

The topography is hilly.

AUCHINBLAE ASSOCIATION

<i>Distribution</i>	An area of about half a square mile around Cairndrum Farm; an area of extensive separate mounds covering about a square mile south of Kirkton of Menmuir; additional scattered mounds occur throughout the arable area.
<i>Parent Material</i>	Red fluvio-glacial sand and gravel.
<i>Dominant Series</i>	Freely drained.

Profile

<i>Horizon</i>	<i>Depth</i>	
S	0-8 in.	Medium brown, coarse, sandy-loam; crumb structure; many rounded stones. Sharp change into
B ₂	8-16 in.	Bright reddish-brown, coarse sandy gravel; loose single grain structure. Merging into
B ₃	16-22 in.	Pale reddish-brown, coarse sandy gravel; rather indurated. Merging into

C 22 in. + Reddish-brown, coarse sandy gravel; single grain structure.

The topography is moundy.

CRAIGO ASSOCIATION

Distribution . The Blair Muir area; a small area north of Little Brechin; an area round Duns Wood.

Parent Material . Red water-sorted deposits overlying red, sandy clay-loam till of Stonehaven or similar type.

Dominant Series . Imperfectly drained.

Profile

<i>Horizon</i>	<i>Depth</i>	
S	0-10 in.	Dark brown loam; crumb structure. Merging into
B ₂ -G	10-14 in.	Pale pinkish-brown, stony sandy-loam; crumb structure; fairly strong rusty mottling. Merging into
C	14-21 in.	Pale, reddish-brown, stony sandy-loam; cloddy structure; faint rusty mottling near top of horizon. Clear change into
	21 in. +	Red-brown, sandy clay-loam till; cloddy structure.

The topography is gently sloping.

BALROWNIE ASSOCIATION

Distribution . Occurs generally throughout the arable area south of the Caterthuns, Ledmore Hill and Standford Hill; it extends eastwards as far as Trinity, and to the west and south is bounded by present survey limits. There are some areas of the Craigo Association within this extent.

Parent Material . Red, water worked deposits and till material of loam to sandy-loam texture, with lenses of heavier and lighter textured material.

Dominant Series . Imperfectly drained.

Profile

<i>Horizon</i>	<i>Depth</i>	
S	0-9 in.	Medium brown loam; crumb structure; no mottling. Sharp change into
B ₂ -G	9-17 in.	Pale reddish-brown sandy-loam, with greyish patches and rusty mottling; cloddy crumb structure above, cloddy and slightly indurated below. Merging into
B ₃	17-25 in.	Dull red-brown loam; with some roughly vertical grey streaking; rather compact, cloddy structure. Merging into
C	25 in. +	Dull brownish-red loam till, cloddy to cloddy laminar structure.

The topography is gently undulating with low east to west ridges. The general slope falls gradually from north to south.

UNDIFFERENTIATED ALLUVIUM

Distribution . . . Small areas restricted to drainage channels and river courses through the area. Texture and drainage are very variable.

SKELETAL SOILS

FLAGGY QUARTZITE

Distribution . . . Hill tops and upper slopes throughout the area north of the Highland Boundary Fault.

Profile . . . Generally thin raw humus over somewhat shattered rock rubble.

HILL PEAT

Limited areas of hill peat are found throughout the same area as the skeletal soils.

SOUTH-EAST SCOTLAND

Roxburghshire (Geological Survey Sheet 17)

ASSOCIATIONS

BOWMONT ASSOCIATION

Distribution . . . Eastern part of the area.

Parent Material . . . Till derived from Upper Old Red Sandstone formation, overlying solid.

Dominant Series . . . Freely drained.

Profile

<i>Horizon</i>	<i>Depth</i>	
A ₀ L	0- $\frac{1}{4}$ in.	Moss and free litter.
A ₀ F	Trace	Partly decomposed plant material.
A ₀ H	Trace	Humus.
A ₁	$\frac{1}{4}$ -8 in.	Reddish-brown sandy-loam; soft cloddy to crumb; uniform colour. Merging into
B	8-10 in.	Light reddish-brown sandy-loam; soft cloddy to crumb; uniform colour.
C	10-16 in.	Reddish-brown, sandy clay-loam till; cloddy; uniform colour.
	16-43 in.	Rotten Old Red Sandstone sediments.

The topography is broadly rolling.

HINDHOPE ASSOCIATION

Distribution . . . Western part of the area.

Parent Material . . . Till derived from rocks of Silurian formation.

Dominant Series . . . Poorly drained.

Profile

<i>Horizon</i>	<i>Depth</i>	
A ₀ L	Trace	Plant material.
A ₀ F	0-½ in.	Partly decomposed plant material.
A ₀ H	½-3 in.	Black greasy humus becoming brown towards base. Merging into
A-G	3-7 in.	Light brown grey loam; cloddy; humus staining associated with plant roots. Sharp change into
G	7-12 in.	Light grey clay-loam; prismatic; ochreous mottling associated with root channels. Sharp change into
G	12-24 in.	Yellow clay-loam; cloddy to prismatic; strong, bright orange mottling; grey, round stones. Merging into
G-C	24-42 in.	Pale yellow clay; cloddy; grey mottling on structural faces and round stones.

The topography is hilly with south-west-north-east ridges clearly defined on the hill slopes.

MINTO ASSOCIATION

<i>Distribution</i>	.	A strip between the Bowmont and Hindhope Associations.
<i>Parent Material</i>	.	Mixed till derived from Old Red Sandstone and Silurian formations.
<i>Dominant Series</i>	.	Poorly drained.

Profile

<i>Horizon</i>	<i>Depth</i>	
S	0-11 in.	Brown, fine-sandy, silty clay-loam; strong cloddy structure; no mottling. Sharp change into
G	11-20 in.	Light yellowish brown, fine sandy clay; strong prismatic structure; grey-coated faces to structural units; prominent black manganese stains; moderate ochreous mottling. Merging into
G-C	20-44 in.	Reddish-brown sandy clay; weak prismatic to massive structure; slight ochreous and grey mottling.

The topography is broadly rolling.

HAWICK ASSOCIATION

<i>Distribution</i>	.	Alluvium of River Teviot from Denholm to Hawick; alluvium of other smaller rivers; lacustrine alluvium within the area of the Hindhope Association.
<i>Parent Material</i>	.	Alluvium of Silurian origin.
<i>Dominant Series</i>	.	Poorly drained.

Profile

<i>Horizon</i>	<i>Depth</i>	
S	0-10 in.	Brown, fine sandy, silty loam; strong, cloddy; uniform colour. Sharp change into
G-C	10-42 in.	Light yellowish-brown, fine sandy, heavy-loam; prismatic; uniform colour.

The topography is flat.

JEDBURGH ASSOCIATION

<i>Distribution</i>	.	Alluvium of Rivers Jed and Rule and other smaller rivers.
<i>Parent Material</i>	.	Alluvium of Old Red Sandstone origin.
<i>Dominant Series</i>	.	Poorly drained.

Profile

<i>Horizon</i>	<i>Depth</i>	
S	0-8 in.	Reddish-brown loam; cloddy; uniform colour. Sharp change into
G-C	8-26 in.	Reddish brown loam; very strong columnar structure; uniform colour. Merging into
	26-36 in.	Light reddish-brown sand; single-grained structure; uniform colour. Sharp change into
	36-42 in.	Gravel; single-grain structure.

The topography is flat.

DENHOLM ASSOCIATION

<i>Distribution</i>	.	Alluvium of River Teviot from Jedfoot to Denholm.
<i>Parent Material</i>	.	Alluvium of Old Red Sandstone and Silurian origin.
<i>Dominant Series</i>	.	Poorly drained.

Profile

<i>Horizon</i>	<i>Depth</i>	
S	0-10 in.	Light brown to brown; very fine sandy, silty loam; strong cloddy structure; uniform colour. Merging into.
G-C	10-32 in.	Light brown to brown; very fine sandy, silty loam; strong prismatic structure; dull colour on structural faces, otherwise uniform colour. Sharp change into
	32-40 in.	Brown sandy gravel; single-grained structure; uniform colour.

SKELETAL SOILS

SILURIAN SEDIMENTS

<i>Distribution</i>	.	Throughout the area of the Hindhope Association where rock is close to the surface.
<i>Parent Material</i>	.	Weathered Silurian rocks.

Profile

<i>Horizon</i>	<i>Depth</i>	
A ₀ L	Trace	Undecomposed litter.
A ₀ F	0-½ in.	Partially decomposed litter.
A ₀ H	Trace	Humus.
A ₁	0-6 in.	Very strong brown loam; crumb structure; uniform colour. Merging into
	6 in. +	Shattered rock.

The topography is hilly.

SOUTH-WEST SCOTLAND

*Ayrshire (Geological Survey Sheet 22)**Northern Region*

ASSOCIATIONS

ASHGROVE ASSOCIATION

<i>Distribution</i>	In a strip four miles broad running north-east-south-west from Auchentiber to Barrmill, west of Lugton Water.
<i>Parent Material</i>	Mixed till of sedimentary rocks, mainly sandstones, together with shale and limestone of Carboniferous formation.
<i>Dominant Soil</i>	Poorly drained.

Profile

<i>Horizon</i>	<i>Depth</i>	
S	0-8 in.	Brown, heavy clay loam; strong cloddy structure; moderate rust staining; faces of structural units dull. Relatively sharp change into
G	8-25 in.	Yellow and grey brown clay; prismatic structure; strong ochreous and grey mottling. Merging into
G-C	25-45 in.	Dark grey brown clay; massive structure; many heavily gleyed decomposed stones.

The topography is undulating.

DARLEITH ASSOCIATION

<i>Distribution</i>	On major part of high ground, bounded by a line joining Dunlop, Longloch and Glenouther Moor in the south, and in the north by a line running just south of Neilston, Balgray Reservoir and Newton Mearns; Lochliboside Hills; high ground north of Beith.
<i>Parent Material</i>	Thin till on basic and intermediate lavas.
<i>Dominant Series</i>	Imperfectly drained.

Profile

<i>Horizon</i>	<i>Depth</i>	
A ₀ L	0-2 in.	Undecomposed grass litter.
A	2-10 in.	Brown loam; nutty structure; stony. Sharp change into
B ₂ -G		Red-brown, heavy loam; amorphous; very stony, slight ochreous staining. Merging into weathering and shattered rock.

The topography is hilly with many rock outcrops.

KILMARNOCK ASSOCIATION

<i>Distribution</i>	Small area south-east of Beith, extending to Barrmill; in the vicinity of Symington (southern region); $\frac{1}{2}$ -1 mile broad strip south of River Irvine from Hurlford to a little west of Fairlie House.
<i>Parent Material</i>	Mixed till derived mainly from lavas with varying sedimentary rock content of sandstone and shale.
<i>Dominant Series</i>	Imperfectly drained.

Profile

<i>Horizon</i>	<i>Depth</i>	
S	0-8 in.	Strong brown heavy loam; cloddy structure. Sharp change into
B	8-30 in.	Red-brown clay loam; prismatic structure; moderate ochreous mottling. Merging into
G-C	30-45 in.	Dark brown, clay loam to clay; weakly laminated structure; slight gleying.

The topography is rolling in the Beith and Symington areas and undulating in the Hurlford area.

GLENMOUNT ASSOCIATION

<i>Distribution</i>	In localised pockets throughout the Ashgrove Association.
<i>Parent Material</i>	Mixed till, derived mainly from shales, with other sediments of Carboniferous formation.
<i>Dominant Series</i>	Poorly drained.

Profile

<i>Horizon</i>	<i>Depth</i>	
S	0-9 in.	Dark brown, heavy loam; strong cloddy structure. Sharp change into
G	9-27 in.	Bluish-grey clay; prismatic structure with moderate grey and ochreous mottling. Merging into
G-C	27-40 in.	Dark brown clay; massive structure; strong grey gleying; high content of weathered shale chips.

The topography is undulating.

ANLAIRD ASSOCIATION

- Distribution* . In a broad belt between the Darleith Association in the north and the Kilmarnock Association in the south.
- Parent Material* . Heavy till derived from basic and intermediate lavas.
- Dominant Series* . Poorly drained.

Profile

<i>Horizon</i>	<i>Depth</i>	
S	0-8 in.	Dark grey brown heavy loam; cloddy. Moderately sharp change into
G	8-17 in.	Yellowish brown clay; cloddy to prismatic structure; strong gleying and iron staining. Moderately sharp change into
G	17-32 in.	Brown clay loam; weak prismatic structure; heavy iron staining and gleying. Sharp change into
G-C	32-43 in.	Reddish-brown clay; massive structure; moderate gleying; many weathered lava stones.

The topography varies between hilly and broadly rolling.

Southern Region

ASSOCIATIONS

DREGHORN ASSOCIATION

- Distribution* . A broad flat area south of the River Irvine, narrowing at the southern tip of Shewalton Moss to form a coastal strip approximately one mile wide.
- Parent Material* . Raised beach sand.
- Dominant Series* . Freely drained.

Profile

<i>Horizon</i>	<i>Depth</i>	
S	0-8 in.	Dark brown, loamy sand; weak cloddy structure. Sharp change into
B-C	8-42 in.	Reddish-brown sand; single grain structure.

The topography varies between flat and gently undulating.

There are many examples of subsidence due to coal mining in the area. As the permanent water table is high, drainage of these depressions presents great difficulties.

ROWANHILL ASSOCIATION

- Distribution* . Inland from the coastal sands with the Inchgotrick Fault forming the eastern boundary.
- Parent Material* . Carboniferous sediments with a high proportion of shales and coal.
- Dominant Series* . Poorly drained.

Profile

<i>Horizon</i>	<i>Depth</i>	
S	0-7 in.	Brown, heavy loam; strong cloddy structure. Sharp change into
G	8-18 in.	Light yellowish-brown clay; well defined columnar structure; strongly mottled with ochre and slightly grey gleyed. Merging into
G	18-26 in.	Brown clay; prismatic structure; marked grey gleying. Merging into
G-C	26-40 in.	Brown clay; platy structure; decrease in grey gleying.

The topography is undulating.

DUNDONALD ASSOCIATION

<i>Distribution</i>	High ground in the vicinity of Dundonald and Craigie.
<i>Parent Material</i>	Teschenite and olivine dolerite lavas.
<i>Dominant Series</i>	Imperfectly drained.

Profile

<i>Horizon</i>	<i>Depth</i>	
S	0-9 in.	Yellowish-brown loam; cloddy structure. Sharp change into
B ₂ -G	9-16 in.	Yellowish-brown clay-loam; prismatic structure; slight ochreous mottling. Merging into
B ₂ -G	16-28 in.	Brown clay loam; ill-defined prismatic structure; moderate ochreous mottling; several large weathering dolerite stones. Sharp change into
C	28-40 in.	Fine sandy clay-loam, composed essentially of weathering dolerite; markedly iron stained.

The hilly region covered by this soil association is deeply gullied and is studded with rock outcrops.

BARGOUR ASSOCIATION

<i>Distribution</i>	South of Glaston and around the lower reaches of the River Cessnock.
<i>Parent Material</i>	Mixed till derived mainly from rocks of Upper Old Red Sandstone formation, with slight carboniferous sandstone and lava admixture.
<i>Dominant Series</i>	Imperfectly drained.

Profile

<i>Horizon</i>	<i>Depth</i>	
S	0-9 in.	Brown loam; cloddy structure. Sharp change into
A	9-14 in.	Strong brown, heavy-loam; prismatic structure. Merging into

B ₂ -G	14-24 in.	Yellowish-red, sandy clay-loam; well-defined prismatic structure; marked ochreous mottling and slight grey gleying. Merging into
C	24-42 in.	Reddish-brown, sandy clay-loam; weak prismatic structure.

The topography is rolling.

LINKS

Distribution . . . Narrow coastal strip from Irvine to Troon and in a number of small areas near Shewalton Moss.

The soil is free to excessively freely drained and has about two feet of light brown sand overlying iron stained yellow-brown sand; buried dark brown humus A horizons are common. Podzolisation with accompanying Fe pan occurs in some parts.

The topography is undulating.

ALLUVIUM

Flat spreads of alluvium are found along every stream, especially the Irvine, Lugton and Cessnock Rivers. Numerous lake deposits have also been mapped, the more important being around Loch Libo, Riccarton Moss, near Inchbean and north of Newfield House. A layer of organic accumulation is often found in these water-laid deposits at from 18-24 inches.

HILL AND BASIN PEAT

Hill and basin peat is scattered throughout the area surveyed, the former being confined to the northern portion as at Glenouther and Moyne Moors and the latter to the southern part in Shewalton and Riccarton Moss.

SOIL HORIZON SYMBOLS USED BY THE SOIL SURVEY OF SCOTLAND (1951)

ELUVIAL HORIZONS

A undifferentiated

Subdivisions of Eluvial Horizons

A₀L undecomposed plant remains.

A₀F partially decomposed organic matter.

A₀H well decomposed organic matter

A₁ intimate mixture organic and mineral matter.

A₂ grey silicious.

GLEYED ELUVIAL HORIZONS

A-G gleyed A.

Subdivisions of Gleyed Eluvial Horizons

A₂-G gleyed A₂.

ILLUVIAL HORIZONS

B undifferentiated.

Subdivisions of Illuvial Horizons

B₁ iron pan, or humus concentration or both.

B₂ diffuse deposition of sesquioxides or humus or both.

B₃ indurated or compacted.

GLEYED ILLUVIAL HORIZONS

B-G gleyed B.

Subdivisions of Gleyed Illuvial Horizons

B₂-G gleyed B₂.

PARENT MATERIAL

C undifferentiated.

GLEYED PARENT MATERIAL

G-C gleyed C.

GLEYS

G undifferentiated.

CULTIVATED HORIZONS

S undifferentiated.



DEPARTMENT OF SOIL FERTILITY



LIBRARY

